THE ILLUMINATING ENGINEER

LIGHT LAMPS FITTINGS AND ILLUMINATION

THE JOURNAL OF

GOOD LIGHTING

Official Organ of the Illuminating Engineering Society

FOUNDED IN LONDON 1908

Edited by LEON GASTER

. OIL . GAS ELECTRICITY ACETYLENE PETROL-AIR GAS ETC.

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Artificial Light as an Aid to Aerial Navigation—Scientific Principles Underlying the Manufacture of Lamps and Valves—A Novel Lighting Exhibition at Rotterdam—Constitution and By-Laws of the Illuminating Engineering Society—An Exhibition of Scientific Apparatus—Illumination as a Production Factor—News from Abroad, etc.

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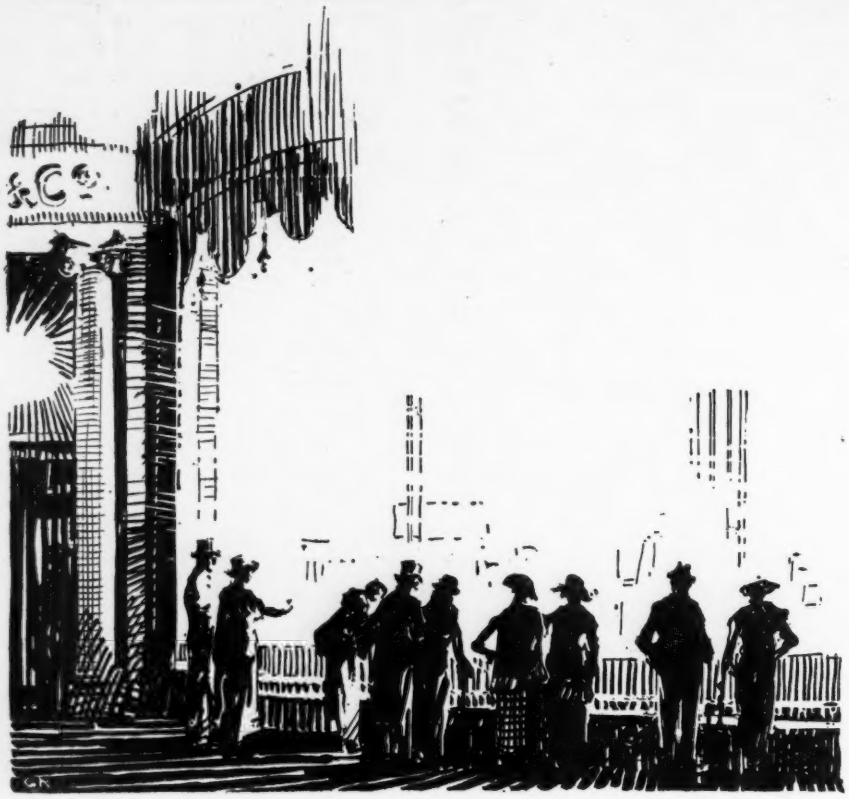

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Artificial Light as an Aid to Aerial Navigation

IT is now just five years since the above subject was last discussed before the Illuminating Engineering Society. In 1922 a very comprehensive paper was read thereon by Lt.-Col. Blandy, D.S.O., and Major-General Sir Frederick Sykes, then Director of Civil Aviation, presided. Since that date considerable progress has been made, and the moment was therefore opportune for the admirable paper read by Mr. H. N. Green (Royal Aircraft Establishment, Farnborough), before the Society on February 22nd. We shall be reproducing this paper and the ensuing discussion in our next issue. Meantime we shall only refer to a few salient points. As on the former occasion, the co-operation of the Royal Aeronautical Society and other bodies interested was invited, and the discussion was fully representative, officers attached to aerodromes, makers of apparatus and others contributing their views.

Mr. Green confined himself to ground lights, i.e., beacons and aerodrome lighting. The design of lights carried by aeroplanes and signalling devices constitutes a different field on which, we hope, something further may be said in the future. The desirable qualities of an aerial beacon are three in number. It should have a distinctive character, should be reliable in operation, and should have a maximum range for a given energy consumption. The choice of the site for a beacon also deserves attention; contrary to expectations, the summit of a hill is not always the ideal spot. The methods of rendering a light distinctive, e.g., by flashes at prescribed intervals, was discussed in some detail. Colour of the light may also prove effective. The strontium beacon, invented by Mr. Toulmin Smith and Captain Davis, was a most ingenious and interesting device; but it has since been superseded by the neon beacon, the unmistakable colour of which, coupled with its capacity for being flashed at rapid intervals, renders it particularly useful for aerial work.

A discussion of the desirable light distribution and beam candle-power of beacons led to an account of the methods being employed for the Croydon-Lympne route. In clear weather the neon beacon at Croydon has been seen by pilots from the French side of the Channel—a striking tribute to its effectiveness. Other distinctive lights are mounted to mark out the London-Paris route. For this purpose incandescent mantles operated by acetylene gas are yielding good service. Considerable progress in aerodrome lighting has been made. The author showed some striking photographic illustrations of the appearance of the landing ground illuminated by modern floodlighting projectors; apparently modern methods enable the aviator to land without being prejudicially affected either by glare or inconvenient shadows. Other interesting features include the boundary lights and the luminous "arrow" devised to indicate the direction of the wind.

Especially instructive was the author's account of the measures taken to counteract, as far as possible, the difficulty of landing in fog. The final stage is accomplished by the aid of illumination. But the pilot has at his disposal other scientific aids. Directional wireless is now in everyday use, and the ingenious "leader cable," carrying a low-frequency current, is also of great assistance in enabling him to find his way safely into the aerodrome.

Thus we see that the scientific devices employed to enable the pilot to fly by night, and even to overcome in a measure the distracting effect of fog and mist, are remarkably varied. The methods of illumination alone include almost all the chief forms of lamps and lighting devices, such as the very high candle-power gasfilled lamps designed for beacons, the floodlighting projectors for lighting landing areas, the neon recognition lights, and the acetylene-operated sources used in situations where no supply of electricity is available.

The great importance of night flying was fully recognized in 1922. Since then many remarkable long-distance flights have been achieved. Railways and steamships can ordinarily make their way continuously by night and day; if aircraft cannot do likewise their advantage in civil aviation, their greater speed, is partially lost. Moreover, a costly machine, such as an aeroplane, can be more economically run if it is able to make journeys both by night and by day, and is thus remuneratively employed for a greater proportion of the 24 hours. The earning power on the capital invested would thus be materially increased. Fortunately science has already gone far to eliminate difficulties in flying on regular routes by night. We may hope that ultimately the effects of fog and mist, which constitute one of the greatest obstacles to further progress, will likewise be overcome. Research is proceeding in all the chief countries, and the problem will doubtless tend to assume, more and more, an international aspect. Agreed methods of requesting and receiving permission to land, of identifying aircraft of different countries, of giving essential information to air travellers, and of inviting assistance in distress will doubtless come into general use. In all such problems illumination will doubtless continue to play a predominant part.

A Novel Lighting Exhibition in Rotterdam

IN this issue we are including an illustrated account, kindly furnished by Dr. N. A. Halbertsma, of the novel lighting exhibition recently arranged in Rotterdam, under the auspices of the Dutch Illuminating Engineering Society, the Museum of Labour, and the Municipal Electric Supply. The exhibition was staged at "The Academy," which is a School of Arts as well as Technical Science, and arranges an exhibition every year dealing with different objects (water colours, furniture, objects of applied art, etc.). On this occasion the display was entitled "Sight and Light," and the various exhibits were all devised with a view to showing how the impressions received by the eye are affected by different lighting arrangements.

In this respect the display differs somewhat from the ordinary exhibition of lighting. It showed the difference between "good" and "bad" methods —and how one form of lighting admirably adapted to certain effects may be quite out of place for others. This was illustrated very clearly by the series of carved objects. In the case of an ordinary bust uni-directional light, especially if wrongly directed, is usually unsuccessful. Even if part of the face is not left in obscurity the shadows on the illuminated portion are too hard and abrupt. Much more pleasant conditions are secured by soft and diffused lighting, which resembles natural daylight illumination. On the other hand, conditions are apparently different in the case of a carving executed in bas-relief. In this case the softer illumination is less effective than the illumination received from a light source of relatively small dimensions. Similar considerations have to be weighed in deciding the best methods of illuminating pottery, glassware, silverware, etc. In such cases it may well happen that the reflection of bright points of light in polished surfaces helps to create the desired impression of sparkle, and consequently it may not be desirable for the illumination to be too completely diffused. Thus the same effect which, when present in excess, gives rise to objectionable reflected glare in industrial operations, may prove beneficial when the question of showing off objects for display purposes is considered.

Other interesting features of the exhibition included demonstrations of the "silhouette effect" as experienced in street lighting, model examples of the lighting of show windows, writing desks, dining-room tables, typewriters, etc., and comparisons between antique bracket and portable fixtures with the very latest forms manufactured to-day. Equally instructive was the section devoted to "camouflage effects." During the war there were many occasions when the aim was the exact reverse of that ordinarily pursued in illuminating engineering, i.e., to conceal objects instead of securing maximum visibility. But under ordinary conditions, for example, in the home, we not infrequently meet instances of unintentional camouflage—e.g., when the design for switches and wallpapers is such that the observer is apt to overlook the presence of the switch altogether.

The whole arrangement of the exhibition reflects great credit on the ingenuity of Dr. Halbertsma and the enterprise of the newly formed Dutch Illuminating Engineering Society, and we trust that in the near future a display on similar lines will be arranged in this country.

Scientific Problems Underlying the Manufacture of Lamps and Valves

THE informative paper entitled "Some Studies in the Manufacture of Electric Lamps and Thermionic Valves," read by Mr. C. C. Paterson before the Royal Society of Arts on February 16th, contained a striking survey of the varied problems underlying lamp manufacture. During recent years automatic machinery has largely replaced hand manipulation. But this circumstance has rendered an exact knowledge of scientific principles all the more necessary. Small deviations from the normal can often be counteracted by hand adjustments; but in the case of an automatic process any departure from standard requirements may play havoc with the output.

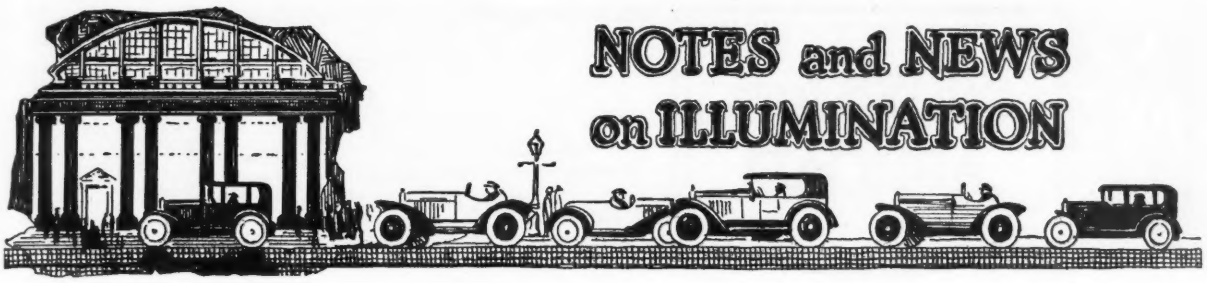
The constituents of the modern lamp are numerous, comprising glass, filament, leading-in wires, supporting wires for filaments, gas (for gasfilled lamps), nickel, molybdenum, and tungsten electrodes (for valves)—all have been the subject of prolonged and systematic research.

One outstanding fact revealed in the paper is that the performance of a lamp depends mainly on the removal of the last possible traces of gases or water vapour, which may not only be present in the bulb, but may also hide in the glass. Hence the ingenious expedient of depositing a special cryolite film on the glass to check the emanation of such occluded gases. The next point is the extremely interesting account of the process of crystallization of the tungsten filament, and the expedients by which this crystal growth is controlled, and inconvenient developments during the life of the lamp are avoided. It is a most curious coincidence that thorium, the element which plays a predominant part in this effect, is also the element which has proved indispensable in the manufacture of filaments for wireless valves, though for quite different reasons.

Many other subsidiary problems were touched upon, such as the search for suitable materials for leading-in wires, and the purification of the gas (argon containing 10 to 15 per cent. of nitrogen) needed for gasfilled lamps.

The great progress made in the manufacture of lamps has been largely a result of standardization. No doubt further limitation of voltages and types and intensive mass production will eventually result in lamps that are still better and cheaper than at present. Mr. Paterson recalled that the total world consumption of the lamps is now about 600 million, of which this country manufacture about 30 million—a small proportion of the total, but in itself a large quantity, which it is hoped will be increased very greatly in the near future.

It would surely be difficult to find a better instance than the lamp industry of the benefits of applied science and research. Not only the striking advances in design, but the equally important improvement in consistency of quality of lamps, have been based on the patient researches of the physicist and chemist. When mass production is attempted a trained scientific staff and adequate experimental resources become of increased importance. We should therefore like to take this opportunity of recognizing the forethought and sagacity which led the General Electric Company to establish their fine research laboratories at Wembley. We are confident that the results obtained there under Mr. Paterson's able direction have fully justified the considerable expenditure involved.



Lighting Problems and Their Solution

We understand that the forthcoming meeting of the Illuminating Engineering Society, on March 22nd, is to be devoted to a novel form of discussion. A series of short subjects will be introduced by different authors, each item occupying about ten minutes. The aim in each case will be to state some problem connected with illumination which presents interesting features, or has occasioned exceptional difficulties, and to explain how these difficulties have been met. The meeting has been arranged to take place at the E.L.M.A. Lighting Service Bureau at 6-30 p.m. on Tuesday, March 22nd. Members who can suggest novel problems for discussion, which they will be willing to deal with at this meeting, are invited to communicate with the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.1).

The Lighting of Printing Works

At a recent meeting of the Joint Industrial Council for the Printing Trades of the United Kingdom reference was made to the recent Report issued by the Illumination Research Committee, the contents of which has already been summarized in this journal. Mr. Goodwin (joint Secretary) pointed out that, according to the Report, at least 20 foot-candles was needed, and few printing offices were at present lighted to this degree. Mr. Yates urged that information concerning lighting should be made available immediately for use in connection with new offices under construction. It was decided to obtain 200 copies of the Report, and issue one copy to each member of the Council and two copies to each District Committee.

Some discussion also took place on the choice of illumination photometers to enable the lighting conditions in works to be studied. Evidently this Report is receiving due attention from the printing industry, and will exercise a marked influence on future lighting schemes.

Institution of Public Lighting Engineers

ANNUAL GENERAL MEETING AND CONFERENCE, BRIGHTON.

In connection with the forthcoming Annual General Meeting and Conference, to be held at Brighton on September 12th, 13th, 14th and 15th, 1927, it is proposed to hold an exhibition of street-lighting appliances (electric, gas or other illuminants). Firms desiring to take part in the same should apply forthwith to Mr. Alex. C. Cramb, M.I.Mech.E., M.I.E.E. (President-elect of the Institution), Electric House, 38, High Street, Croydon, Surrey, stating their requirements as to floor space, and if they require a supply of electricity or gas in connection with their exhibit.

The History of Artificial Lighting

We are informed that Capt. W. J. Liberty has been awarded a Premium for the paper read by him before the Institution of Engineers on "The History of Artificial Lighting" in October last. The Premium was presented to Capt. Liberty at the meeting of the Society on February 7th.

The "I.E.S." Spirit

In a message published in the last issue of the *Transactions* of the Illuminating Engineering Society (U.S.A.), the President (H. H. Higbee) thus defines "the I.E.S. spirit":—

"It is not sufficient that we should merely recognize as leaders particular persons who chance to have it or who strive to develop it, for to be really effective it must actuate the mass of us. It should not merely be a spirit which enables us to forget personal or business advantage as we serve the Society and the profession, but be also a motive impelling us all to serve our Society and our profession, to develop them and ourselves to the highest degree. It should be a spirit which draws us into the Society for the reason that we are genuinely interested in its purposes and strivings rather than merely because it is good for our business, and which therefore causes us to retain our interest and our membership, even if our business should not urge; a spirit which causes us to look forward to an occasional meeting of fellow-enthusiasts interested in the science and art of lighting as we might look forward to any other pleasurable contact or activity, so that we do not have to delegate to an Attendance Committee the onerous task of inducing us to attend things that are good for us. It should be a spirit that moves us to study earnestly along the line of our professed interest, even though this require real mental effort, so that those who have worked to produce something of value to us, often at great sacrifice because of the spirit that is in them, shall not always be asked to make further sacrifice of their time in order to serve it to us in some special way designed to intrigue our interest and demand no effort from us; a spirit that induces us to strive to generate new ideas for improvement of our science and art, and be willing to do such work as may be involved in carrying them out; a spirit . . . which moves us to serve with enthusiasm and initiative as officers and on committees, and, without delegating the matter entirely to a Membership Committee, go out of our way individually to impart to others the interest that makes us glad we are members of the I.E.S."

Playing Tennis by Night

One of the chief developments in "lawn tennis" during recent years has been the great increase in the number of hard courts. The skill of Continental players is attributed very largely to their use of hard courts, which can be used all the year round and are rarely put out of action by weather conditions. Unfortunately there is another great limitation to winter-play, apart from weather conditions, viz., lack of daylight. The idea of providing artificial lighting for courts, so that play can proceed during the evenings, is making some headway. The chief trouble is the cost which makes the charges to players very heavy—indeed almost prohibitive to most people if lighting on the scale available at the Queen's Club and similar institutions is provided. Electricity supply undertakings could do much to help matters by granting reasonable rates, seeing that the load comes on after the peak and might extend far into the night. This course should be rendered easier when the electrical supply is municipal. Local authorities now quite frequently own hard tennis courts which are open to the public. We notice that the Leeds Park Committee has decided to invite tenders for the electric lighting of four courts at Roundhay.

Efficient Library Lighting

A contribution to *The Electrical World* by M. M. Samuels and J. T. Holmes describes a somewhat novel method of lighting that has recently been installed in the Engineering Societies' Building, New York City. The original installation, though doubtless as good as was available at the time it was put in, had many faults, one of the chief defects being the inequalities of illumination produced by the table lamps, the variations being in some cases as much as 70 per cent. in a distance of two feet. For various reasons cove lighting and indirect methods were ruled out of court. The ceiling was too dark, and it could not be lightened without destroying the architectural balance of the room. Ultimately a special form of fitting was designed. The description sounds rather elaborate, the chief features being "a central lamp, a surrounding reflector directing the lighting downwards, a diffusing panel beneath this to enlarge the apparent sources of light and reduce the intrinsic brightness, a surrounding cylinder of translucent glass of suitable texture and coloured to harmonize with the woodwork, and finally an upward component producing a soft light intensity on the ceiling." In spite of its somewhat complicated design, the lantern is said to be pleasing in appearance, and there is now no glare whatever. The illumination on the reading tables, 4½ foot-candles, is almost uniform, and there is sufficient vertical illumination to enable titles of books on shelves to be read with ease. An important feature is that the new fitting could be introduced without any disturbance of the existing wiring, and the removal of the local table lamps means a considerable saving in energy.

The Prospects of Television

A television projector which is believed to have hopeful possibilities was recently described in an address by Dr. E. F. W. Alexanderson (Consulting Engineer to the General Electric Co. of America and the Radio-Corporation of America), in an address to members of the St. Louis section of the American Institute of Electrical Engineers. Radio-transmission of a single photograph has been effected in two minutes; but television will require the transmission, reception, and reproduction of a single picture in 1-16th of a second.

It is, he suggests, comparatively easy to design a television system with about 40,000 picture units per second, but the images so obtained are crude, and would have no practical value. An operating speed of 300,000 pictures per second will be needed to give pleasing results.

The television apparatus which Dr. Alexanderson has in operation in his laboratory will, it is believed, furnish the 300,000 brush strokes necessary for producing motion pictures.

. The method involves the use of seven distinct light sources converging in a cluster of brilliant lights, which scan the picture; each light painting a crude picture, but all seven interlacing optically to produce a single good one. The converging light falls on a revolving drum carrying 24 mirrors, which reflect the light cluster on to a screen. By using seven lights instead of one the useful illumination is increased 449 times, and, in addition, the speed at which each beam of light must travel is reduced in the ratio of 7 to 1. Thus only 43,000 instead of 300,000 independent impressions per second are needed—a modulation speed which is within reason, being only ten times as fast as is used in broadcasting.

Corresponding to the seven light-spots are seven photo-electric cells, which control a multiplex radio system with seven channels. If the signal is strong enough to be recorded at all, it gives the same kind of records at maximum and minimum signal strengths. Hence the record is independent of fading. Moreover, by introducing a threshold value of suitable strength, the effects of statics can be eliminated.

The Design of Portable Desk Lamps

We notice in the *Sudd. Elektro-Anzeiger* some sound comments on the equipment of desks and writing tables. Users of desks vary greatly. The unmethodical person may approach the conditions humorously described by Mark Twain, whose desk was usually so encumbered with books, newspapers, etc., that he did all his writing on his knees! A tidy person will keep the surface of the desk clear enough to leave ample space for writing, but there are frequently occasions when most of the desk surface is necessarily occupied by papers needed for reference. For this reason desks should be lighted in such a manner that the whole area is evenly illuminated. One cannot be content with a portable unit illuminating only a small circle—any more than one would be satisfied with a lighting unit in the dining-room which lighted up only the centre of the table. Desks are probably most effectively illuminated when a pendant can be arranged a few feet above the working area. A stand lamp can hardly be expected to illuminate evenly a large area of desk or writing table; hence such units can only be relied upon to give extra strong illumination over a limited area, and are supplementary to moderate general illumination. Most people would probably agree that the general illumination should not be less than 3 foot-candles. The illumination from the stand lamp, which may attain 20 foot-candles or more, is additional.

Does Daylight Cost Nothing?

It is also interesting to observe that the journal quoted above has been pointing out to its readers that daylight, contrary to the common impression, does not cost nothing as compared with artificial light. As a matter of fact, the installation of windows, a necessary apparatus for the admission of daylight, means additional initial cost. The cleaning of them and the additional expenditure on heating owing to the chilling effect of the glass, constitute "running costs" of daylight. This point was, we believe, first strongly emphasized in the United States, where the question has been raised whether it is worth while to install costly light-wells, etc., in the case of buildings in congested areas; the space thus sacrificed, it is suggested, might well be put to remunerative use, and reliance placed solely on artificial light. Similar ideas are evidently now being discussed in Germany.

Modern Practice in Street Lighting

It is interesting to observe that modern practice in street lighting is receiving attention in many parts of the world. A recent issue of *The Electrical Engineer of Australia and New Zealand* contained an article summarizing the chief requirements, namely, (1) sufficient illumination, (2) even distribution of light, (3) absence of glare, (4) pleasing appearance by day as well as by night, and (5) economy in cost of installation and operation. Comparisons between results obtained with symmetrical and asymmetrical systems of lighting were also made.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Some Studies in the Manufacture of Electric Lamps and Thermionic Valves*

By C. C. PATERSON, O.B.E., M.I.C.E., M.I.E.E., F.Inst., P.

THE methods used in the manufacture of electric lamps have undergone a radical modification during the past decade. Processes have changed from hand manipulation to mass machine production. Glass bulbs, formerly blown individually by a skilled glass-blower, are now handled entirely by machines. Even in the case of the filament much of the work is now carried out by automatic processes with very little handling. Ten years ago the output of ordinary lamps during the final stages of manufacture was at the rate of three per operator per hour. To-day it frequently touches 25 per operator per hour. The total world consumption of lamps at the present day is 600 millions per annum, of which this country manufactures and consumes about 30 millions. This may sound a small proportion of the total, but 30 million lamps is in itself a large quantity, and one which will be clearly increased greatly in the future.

The valve, thermionic or otherwise, is a newer product. Its development is affected on the one hand by the desires of those in favour of standardization and efficient production; and, on the other, of those who find in the many possible variations in design opportunities of obtaining interesting results and combinations in wireless work. Hence whilst the production engineer can plan in terms of hundreds of thousands of a type, he must, in the case of the valve, be content to work with tens of thousands.

Contrary to the impressions of the casual onlooker, a change from hand manipulation to automatic mass production requires a surer knowledge of the phenomena underlying each of the processes involved. Thus, under hand-working conditions, variations in the viscosity temperature coefficient of the glass or lack of uniformity in this respect from bulb to bulb can be counteracted by the worker, owing to the control he can exercise over his gas flame and glass manipulation. But under automatic machine working conditions a change of this property necessitates a corresponding change in speed of automatic machines, and lack of uniformity may produce chaos in a modern factory.

The main constituents entering into the manufacture of lamps and valves are: glass, filament, leading-in wires and other metal-to-glass junctions, supporting wires for filaments, degree of vacuum, gas (for gasfilled lamps), nickel, molybdenum and tungsten electrodes for valves.

For metals carrying electricity into vacuum vessels, and for other glass-to-metal junctions, platinum is the material most naturally adaptable, but it is costly. Moreover, a material whose coefficient of expansion can be varied according to that of the glass used is often advantageous. By coating with copper nickel-iron alloys of a definite composition this requirement can be met. For supports molybdenum is preferred. The gas used in gasfilled lamps is argon, containing 10 to 15 per cent. of nitrogen. As prepared by the liquefaction and subsequent fractional distillation of air, the argon gas contains considerable quantities of oxygen, which has to be removed, and the gas supplied to lamps in a state of great purity, so far as non-inert constituents are concerned, and of which the chief are water vapour, oxygen and hydrogen.

A high vacuum is essential in lamps and valves, but for each device the reason varies, and likewise the degree of vacuum required. In lamps of the 230-volt vacuum type gas present causes "flashing," i.e., a destructive discharge inside the lamp, which destroys it. In lamps of the 100-volt vacuum type the gas causes "dull burning," i.e., a very hot bulb and lowering of filament temperature, with corresponding loss of light. In gasfilled lamps the presence of gas acts as a species of cancer, causing alternate growths and wastage. In ordinary transmitting valves gas present causes wastage of the filament through bombardment by the gas molecules, and in dull-emitting receiving and transmitting valves it poisons the filament surface with a contaminating gas layer, through which the electrons cannot pass.

Whatever the symptoms, the removal of the last traces of gas is most important. In our study of this "residual gas" we can ignore the ordinary air in the bulb. This is easily extracted. Much more serious is the gas which comes from the glass and metal electrodes. "Metal gas" does not present the same difficulties as "glass gas." The former is more easily removed. The latter, besides being found in solution in the glass, is also found simply attached to its surface. One of the chief methods of eliminating this difficulty is by the deposit of a new and gas-free surface to which fresh molecules will adhere. For lamps it is essential that this coating should be transparent, and phosphorus vapour mixed with cryolite answers requirements well. Phosphorus has also in itself valuable properties which aid in clearing up residual gas. For thermionic valves of relatively small size transparency of the deposited material does not matter, and vaporized magnesium is generally used.

The tungsten used in filaments must possess a number of qualities. It must be capable of being drawn down easily to the finest sizes—to a diameter of 2/100ths of a millimetre. It must be able to be coiled in a close spiral whose internal diameter is not more than three times the diameter of the wire itself. Thirdly, it must withstand a temperature of from 2,500° to 2,900° K., which is about 80 per cent. of the melting temperature of tungsten.

Just as the degree of vacuum in a lamp is mainly

* Abstract of a lecture given before the Royal Society of Arts, February 16th, 1927.

determined by the efficacy of the sudden clean up of the gas which takes place when it is first lighted, so the degree of stability and robustness of the filament are settled within a very short space of time at its first lighting up. At that moment the whole internal structure of the tungsten is completely changed. At the moment the wire reaches lamp-filament temperature we want it to recrystallize rapidly into long crystals, each of which shall occupy many turns of the coil, or, alternatively, to develop a structure having a number of well-interlocked crystal boundaries. In 1920 Goucher grew crystals of indefinite length from ordinary drawn crystalline wire; it had no boundaries at which crystal growth could take place, and therefore showed no tendency to change its form. If, however, either of these single crystal wires were coiled it resented the change of form, and tended to twist back again on prolonged heating. Thus the only satisfactory single crystal filament would be one in which the crystal growth takes place after the coil has been made. It is now possible to obtain tungsten wire coils in such a condition that when the crystals have grown as the result of lighting up the filament, individual crystals embrace 20 to 50 turns of the spiral.

We have yet to determine the precise extent to which very small traces (less than 0.01 per cent.) of certain impurities affect the size and form of the crystal after setting. Two classes of impurity are deliberately added; thoria (about 0.7 per cent.) to restrain crystal growth, and alkalis plus silica or thoria to exaggerate it. A filament of pure tungsten gradually increases in crystal size during life. Hence the coils of the filament tend gradually to yield under gravity. To counteract this effect we may pursue either of two methods. Either a growth-restraining constituent can be incorporated, with a view to retaining the initial fine-grained structure throughout the life; or such rapid and exaggerated growth can be achieved that all crystal movement is complete within a second or so of lighting up the filament, so that there is no time for sagging to take place.

The properties required from tungsten filaments used in valves are very different from those required for lamps. It is an extraordinary coincidence that the same ingredient, thoria, is required, though it serves a totally different purpose. The "dull-emitting" property of tungsten filaments depends upon the maintenance of a molecular layer of thorium on the surface of the tungsten. The layer is readily contaminated by minute traces of oxygen containing gases and vapours—hence the need of a good vacuum in this case also.

The difficulties of the technique and study of this work must be borne in mind by recalling that many of the filaments under consideration are of the order of only 0.02 mm. diameter—a size which has the same relation to an ordinary sewing needle as the diameter of the needle has to that of the wrist of the person using it.

The Utilization of Thermal Energy of the Sea

French journals have been giving publicity to an idea suggested by two engineers, MM. G. Claude and P. Boucherot, based on the use of the thermal energy of the sea as a source of mechanical power. The idea is not entirely new. In some localities, especially in tropical regions, there is a material difference in temperature at the surface of the sea and at some depth. The difference may approach 20° when a depth of 1,000 metres is considered. *L'Electricien*, in discussing the project, points out the very considerable practical difficulties, such as the delicacy of the mechanism to be operated and the low vapour-pressure resulting from a difference in temperature of only 20°. In any case, it can only be in exceptional circumstances, such as those prevailing in the tropics, that the idea can be considered at all. In Europe we have before us an idea that appears much more feasible, and yet has so far been found practicable only on a relatively small scale—the utilization of the tides.

A New Lamp for Motor-Headlights

During recent years the idea of double-filament lamps for automobile headlights have found favour, the idea being to utilize one filament at the focus of the reflector to provide the powerful driving beam, and the other, which is situated somewhat out of focus, to give a depressed beam or a more diffused light. The main driving beam can be switched off in towns, or when passing another car, leaving only the depressed beam, which is free from dazzle. The same idea is embodied in the "Bilux" lamp introduced in Germany, but the design has some special features. The filament to provide the main beam is mounted below the other, both filaments coinciding with the axis of the lamp. The second filament (intended to produce the depressed and more diffused beam) thus falls somewhat in front of the focal point when the lamp is inserted into the reflector, and the two filaments lie along its horizontal axis. Underneath the second filament, and inside the bulb, a small metal shield is mounted. Thus only rays striking the upper region of the reflector are allowed to pass; the result is a beam strongly inclined downwards, and also diffused so as to reach the sides of the road. The main beam enables objects to be recognized at distances of 200-250 metres.

Utility Requirements for Street Lighting*

In a recently issued street-lighting service manual the Public Service Company of Northern Illinois has stated definitely and clearly the requirements of customer-owned street-lighting systems if they are to be connected to its lines. Perfect understanding of these requirements by salesmen and prospective users are expected to do much for the maintenance of harmonious relations. Quoting from the manual, the requirements are: —

A.—The customer shall furnish the entire installation.

1. For an ornamental street-lighting system, including the lighting units, lamps, lighting unit standards, underground cables, transformers, time switches and the constant-current street-lighting regulators for supplying constant current from the company's existing constant-potential system.

B.—Repairs and maintenance expense to be borne by customer.

1. The customer shall bear the expense for all repairs and replacements for an ornamental street-lighting system, excepting the renewal of incandescent lamps, the cleaning of globes and the patrolling of the system, including winding and setting time switches.

2. If the customer desires the company to do the actual repairing and maintenance of posts, globes and other appurtenances thereto, the customer shall pay for such repairs and maintenance at the company's standard rates for time and material.

C.—Repairs and maintenance expense to be borne by company.

1. The company shall bear the expense for renewals of burned-out or otherwise defective incandescent lamps and shall clean the lighting unit glassware and patrol the lighting system.

D.—The company shall furnish all electrical energy.

1. For lighting the lamps of all sizes, types and burning hours specified by and contracted for by the customer. No other electric lighting service shall be used by the customer on the same installation in conjunction with the company's service, either by means of a throw-over switch or any other connection.

Service Connection.—When the installation of the street-lighting system has been approved by the company, the company shall, at the expense of the customer, connect said street-lighting system to the company's existing electrical distribution system at the nearest available point or points, such point or points to be designated by the company.

* Abstracted from *The Electrical World*.

Constitution of The Illuminating Engineering Society*

(FOUNDED IN LONDON, 1909.)

NATURE AND AIMS OF THE ILLUMINATING ENGINEERING SOCIETY.

1. The name of this Association shall be the Illuminating Engineering Society.

2. Its objects shall be the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto. Among the means to this end shall be meetings for the presentation and discussion of appropriate papers; the publication as may seem expedient of such papers, of discussions and communications; and through committees, the study of subjects relating to the science and art of illumination, and the publication of reports thereon.

Also the organization of, or participation in periodical national and international exhibitions of developments in illumination, and congresses dealing with the subject.

MEMBERSHIP.

3. The members of this Society shall be designated Members, Honorary Members, or Corresponding Members.

4. A member may be anyone interested in the objects of the Society, but at the date of election shall not be less than twenty-one years of age.

5. Honorary Members may be chosen from among those who are of acknowledged eminence in some branch of science related to illuminating engineering, or who, by reason of position, eminence, or experience, may be enabled to render assistance in promoting the objects of the Society. Honorary Members shall be entitled to all the privileges of Membership except the right to vote and to hold office therein.

6. Ordinary, Honorary, and Corresponding Members may be of either sex and of any nationality. The masculine pronouns, when used in these Statutes and By-laws, shall be read as applying to both sexes.

OFFICERS OF THE SOCIETY.†

7. The Officers of the Society shall include a President, not more than twenty-five or less than ten Vice-Presidents, an Honorary Secretary, an Honorary Treasurer, and the Council, of which the President, the Hon. Secretary, and the Hon. Treasurer shall be ex officio members.

8. The President shall hold office for one year only, and shall then be eligible for re-election; but his period of office shall not exceed three successive years. The Vice-Presidents, the Hon. Secretary, and the Hon. Treasurer shall hold office for three years and shall be eligible for re-election at the conclusion of their period of office.

9. The Council shall contain representatives of different interests, trades, and professions concerned with illumination and allied subjects, who may be of different nationalities, and shall be so selected that those who have opposing interests commercially shall be equally represented on the Council as far as numbers are concerned, and, if possible, distributed in the following proportions:—

Three engineers prominently connected with gas lighting.

Three engineers prominently connected with electric lighting.

Three engineers connected with other systems of lighting (acetylene, petroleum, petrol-air, etc.).

Three manufacturers of illuminating apparatus, representing different systems of lighting, respectively, or interested in all.

Three Members representing the electrical supply companies, the gas companies, and the consumer, respectively.

Three Members connected with the architectural profession, surveyors, etc.

Three Members connected with physiological aspects of illumination and representative of the views of oculists and ophthalmists.

Three Members interested in general physical science and photometry.

Three members interested in the supervision of the illumination of public buildings, factories, schools, etc., representatives of fire insurance companies, etc.

The total number of Members of the Council shall not be less than eighteen or more than twenty-seven, and the different classes shall, as far as possible, be represented in equal proportions. In the event of additional members being added, the balance of the Council shall be, as far as possible, maintained.

10. One-third of the Members of the Council, representative of different trades or professions connected with illumination, shall retire each year; the retiring Members shall be determined by ballot, in order of seniority of office, but the original Council shall hold office for three years. The positions of retiring Members must be filled by Members representing, as far as possible, the same classes as those of the retiring Members.

11. A vacancy in the office of President shall, in the absence of any nomination by the Council, be temporarily filled by the senior Vice-President. Vacancies in the office of Vice-President shall be temporarily filled by nomination by the Council.

ADMISSION OF MEMBERS.

12. An application for admission to the Society shall be made in a form prescribed by the Council, and shall refer to at least two Members of the Society; or if an applicant should be not personally known to two Members, references may be accepted to Members of professional societies of good standing, or to other persons whose good standing may be readily verified by the Council. If, in the opinion of the Council, further support for a Member's candidature be considered necessary, the recommendations of four existing Members shall be deemed sufficient; but the final consideration of a nomination for Membership rests with the Council.

13. Candidates for admission as Members must present a suitable form of application signed by two or more nominators, as directed above, as follows:—

"We hereby recommend [here state name in full, date and place of birth, rank, profession or business, usual place of residence, and qualifications for Membership of the candidate] as a fit and proper person to become a Member of the Illuminating Engineering Society [here must follow the names of two or more nominators, one of whom must have personal knowledge of the candidate]."

14. Applications will be considered at the next Council meeting after they have been received. The names of

* *The Illuminating Engineer*, London, June, 1909.

† In accordance with the arrangement entered into by the Council with various scientific, professional and technical bodies, the Presidents of these bodies become Honorary Members of Council during their tenure of office, and their presence is invited at meetings at which subjects of common interest are discussed. These bodies include: The Institution of Gas Engineers, The Institution of Electrical Engineers, The Institution of Municipal and County Engineers, The National Gas Council, The Council of British Ophthalmologists, The Ophthalmological Society, The Physiological Society, The Municipal Electrical Association, The British Electric and Allied Manufacturers' Association, The British Electrical Development Association, The Electric Lamp Manufacturers' Association of Great Britain Ltd., The Electrical Contractors' Association, The Society of British Gas Industries, The Institution of Public Lighting Engineers, The Women's Electrical Association. In addition the Presidents of the Illuminating Engineering Societies in the United States of America, Germany, Austria, Holland, and Japan are created Vice-Presidents during their tenure of office.

those whose nominations have been accepted by Council will then be read out at the next meeting of the Society, and will be balloted for at the Meeting following. A majority of two-thirds of those present shall entitle a candidate to election.

15. Due notice of their election shall be sent to the newly elected Members, together with the form of assent for signature.

16. No person shall be entitled to any of the privileges of Membership until the annual subscription, or such other sum as is specified elsewhere as a composition in lieu of annual subscriptions, shall have been paid, and until the member shall have signed the following form:—

> "I, the undersigned, desire to become a Member of the Illuminating Engineering Society, and hereby promise that, if elected, I will submit and conform in all respects to, and be governed by, the terms and provisions of the Constitution and the By-laws made in pursuance thereof; provided that whenever I shall signify in writing to the Hon. Secretary that I am desirous of ceasing to be a member thereof, I shall be free from this obligation, after payment of any Annual Subscription or arrears which may be due from me at that period."

17. A Member may resign from the Society by a written communication to the Hon. Secretary, which resignation shall be accepted by the Council if the Member's subscription and other fees have been duly paid.

18. Honorary Members shall be nominated by the Council or proposed in writing by at least fifteen Members, and shall then be elected only by a four-fifths majority of the Council. The number of Honorary Members elected in each year shall not exceed three. Voting shall be by letter-ballot. A person elected an Honorary Member shall be duly notified by letter. If an acceptance is not received within six months after the dispatch of such notice, a second notice shall be sent, and if again no reply is received within an adequate period not exceeding six months, the election shall be considered void.

19. Foreigners and others not residing in Great Britain or Ireland, on election by a two-thirds majority of the assembled Council of the Society, may become Corresponding Members, without payment of subscription, and may attend, but not vote, at General or Ordinary Meetings, and they shall be entitled to receive *The Illuminating Engineer.*

Expulsion of Members.

20. Upon the receipt of a written request of not less than ten members that, for cause definitely stated in detail, a Member of the Society should be expelled, the Council shall consider the matter, and, if there appears to be sufficient cause, shall advise the Member concerned of the charges against him. The Member may then present a written defence and appear in person before a meeting of the Council, who, within two months shall finally consider the case, and if the defence be deemed not satisfactory, the accused Member shall be requested to resign and, in the event of his refusing to do so, shall be expelled upon a two-thirds vote of the total Membership of the Council.

Subscriptions.*

21. The annual subscription to the Illuminating Engineering Society shall be one guinea, which shall include the subscription to *The Illuminating Engineer*, the appointed official organ of the Society. After the first year the Council shall have power to alter this annual subscription, if found necessary in the interests of the Society; but the subscription shall not exceed two guineas within the first five years of the existence of the Society.

22. Honorary Members shall be exempt from all subscriptions.

23. Any Member may commute or compound for all future payments and become a Member for life, by payment of a sum not less than ten guineas.

24. The Council shall have power in each year to admit, by a three-quarter majority of the entire Membership of the Council, three persons who are eminent in the science and art of illumination, or who have rendered special services to the Society, but are not, at the time being, members of the Council, to be Life Members of the Society without the ordinary formalities of election, and without any subscription whatever, but having all the privileges of membership.

25. Subscriptions shall be dated quarterly, becoming due at the commencement of the quarter in which the member applies to join the Society (i.e., on the first of January, April, July, and October respectively.)

26. If the annual subscription of any Member residing in the United Kingdom shall be in arrear for one year, the Hon. Secretary shall give notice thereof to the Member; and if the said subscription shall continue in arrear at the expiration of six months after such notice, the Council having, through the Hon. Secretary, given the defaulting Member due notice of their intention, shall have power to strike the name of such Member off the register, and he shall thereupon cease to be a Member of the Society, but shall remain liable for any arrears of subscription which shall be due at the date of cessation of Membership; and it shall be the duty of the Hon. Treasurer to recover from persons who shall have ceased to be Members any arrears which may remain unpaid.

27. A defaulting Member may be reinstated by the Council and retain his original date of election upon payment of all back fees, being then entitled to a complete file of the publications of the Society to date, if in stock.

Meetings of the Society.

28. At Ordinary Meetings papers or demonstrations relating to some aspect of illumination or allied subject shall be read or performed, and will be followed by discussion on the part of the members present. Ordinary Meetings may also be set aside for debate on a prescribed subject approved by the Council, or for the discussion of papers read at other societies and in other countries falling within the scope of the interests of the Society, as the Council may direct.

29. A Member of the Society is at liberty to introduce a visitor at an Ordinary Meeting, and visitors so introduced may participate in the discussion, subject to the approval of the Chairman.

30. The chair shall be taken by the President at meetings of the Society, or, in his absence, by a Vice-President or some Member of Council or other Member selected at the meeting.

31. The Council shall have power to invite a distinguished visitor to deliver a lecture before the Society, which shall not be open for discussion, or to read a paper which shall be duly discussed in the ordinary way.

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* The Subscription Rates were altered to the values now ruling in the year 1919, and the following is an extract from the Report of the Council presented at the Annual Meeting on June 24th, 1919, specifying these changes:—

"In accordance with the powers conferred by the Constitution, the Council has accordingly decided, in the interests of the Society, to alter the Annual Subscription of Ordinary Members from One Guinea to Two Guineas, the increase to commence with subscriptions falling due in October, 1919. The subscription for Life Members shall be not less than Fifteen Guineas.

"It is further proposed that persons who are over the age of 16 years and are students at technical colleges, or persons over the age of 21 years who, while not technically connected with the lighting industry, sympathize with the aims and objects of the Society, and whose co-operation would be beneficial thereto, shall be eligible as "Associates." The subscription for Associates shall be not less than one guinea per annum. Associates will have the privilege of attending the meetings of the Society and receiving the official organ, but shall not have voting power nor be eligible for office.

"Students who are continuing their education, and who propose to become professionally connected with the lighting industry, shall have the option of being transferred to the class of members after attaining the age of 21 years; but shall not remain in the class of Associates after attaining the age of 25 years. In the event of their not being so connected they shall be free to continue the class of Associates.

"Existing Members who are professionally associated with the lighting industry shall continue their membership at the increased subscription of two guineas per annum; but existing Members who are not so professionally connected shall have the option of applying to be transferred to the class of Associates at a subscription of not less than one guinea.

"The determination of the class for which an applicant is eligible shall rest with the Council."

32. No decision on the merits of a paper read or lecture delivered before the Society shall be taken at the meetings.

33. No paper can be read at any Ordinary Meeting of the Society unless it shall have been approved by the Council, but this approval shall not be taken as expressing an opinion upon the statements made, experiments described, or results arrived at in the course of such a paper.

34. The Session shall commence in November, the first Ordinary Meeting being held on the third Tuesday of this month. Ordinary Meetings shall, when possible, take place at 8 p.m. on the third Tuesday in each month. The Session shall terminate on the third Tuesday in May.

35. Any Special General Meeting, for a specified object, may be called by the Council, or upon a requisition to this effect signed by not less than fifteen Members, which must be received by the Council at least six weeks previous to the date of such a Meeting.

Notice of the holding of such a General Meeting, and of the purpose for which it is convened, shall be given in the number of the official organ of the Society published previous to the holding of the meeting.

36. No business shall be transacted at a special General Meeting for any purpose other than that for which it shall have been convened.

37. No Member whose subscription is one year in arrear shall be entitled to be present, debate, or vote at any General Meeting.

38. Motions made at General Meetings of the Society shall be in writing, and signed by the mover and seconder.

39. A quorum of the Society shall consist of not less than ten Members.

40. A Meeting of the Council shall take place, each month, on the day on which the Ordinary Meeting of the month is held. Five Members shall constitute a quorum.

41. A Conversazione may be held during the year where any novelties in connection with illumination or objects or processes of special interest may be made the subject of exhibition, if, in the opinion of the Council, their interest merits this display. Should the Council deem it desirable to hold such a Conversazione and to arrange for exhibitions of the character referred to, a Special Committee shall be appointed to consider the matter and undertake the organization thereof. At this Conversazione each Member shall be entitled to invite a friend, and the Council shall also have the power to issue special invitations.

Proceedings at the Annual General Meeting.

42. The Annual General Meeting shall be held on a day in the month of June, and none but Members, Officers of the Society, or persons specially invited by the Council, shall be permitted to be present.

43. At this Meeting the Council shall render to the Society a complete account of their proceedings, a statement of the financial position of the Society, and of the receipts, payments and expenditure during the present year. Previously to the Meeting the Council shall select two Hon. Auditors who will report upon and sign the balance sheet for the year, a copy of which will be circulated among the Members of the Society previous to the Meeting.

44. At the General Meeting the election of Officers to replace vacancies, owing to death or retirement, shall proceed as directed elsewhere.

45. Any alteration in the statutes or by-laws of the Society can only be proposed at the Annual General Meeting, but notice must be given to the Council of any motion to this effect, or relating to any other special business which it is desired shall be discussed at the General Meeting, not later than the last day in March.

46. Notice of the General Meeting shall be published in *The Illuminating Engineer* at least one month previous to the holding thereof.

47. In the absence of the President at the Annual General Meeting the chair shall be taken by a Vice-President or some Member of Council selected by the Meeting.

Election of Officers at the Annual General Meeting.

48. Previous to the General Meeting the Council shall notify all Members of the Society of vacancies on the Council, due to the retirement of Members, and of any other vacancies that periodically recur. They shall also send to each Member, not later than 1st of May, a complete list of the existing Officers and Members of Council, of the retiring Members, and of nominations put forward to fill the vacancies.

49. An application, to which the signatures of not less than ten Members are attached, shall, however, entitle the said ten Members to nominate another candidate, in addition to those named by the Council, to fill the existing vacancies. Such applications must be received by the Council not later than April 15th.

50. Two Scrutineers, who will examine and report upon the result of the ballot, shall be appointed at the Meeting. The candidates receiving the majority of votes will be duly elected, and their elections shall be announced by the chairman.

Management.

51. The Council shall transact all the ordinary business of the Society, undertake its general management, and from time to time may issue such regulations as they think fit for the welfare thereof.

52. Proposals to amend this Constitution shall be made in writing to the Council and signed by at least fifteen Members, and shall reach the Hon. Secretary not later than the last day in March. The Council shall consider such proposals and direct the Hon. Secretary to arrange for a letter-ballot on their adoption. Replies to be considered shall be received not later than May 15th, and shall be referred unopened to the scrutineers appointed by the Annual Meeting, who shall count such votes and report thereon. An affirmative vote of two-thirds of the entire vote cast by qualified Members of the Society shall be necessary to secure the adoption of an amendment. An amendment shall take effect twenty days after its adoption.

53. If no quorum be present at a Meeting called to consider an alteration in the Constitution of the Society, the Council shall proceed to call a second meeting not later than two months after the first before a decision in the matter can be taken.

54. By-laws in interpretation of the spirit and letter of this Constitution, and for its execution, may be adopted by a majority vote of two-thirds of the entire Council. Votes on By-laws shall be by letter-ballot.

55. At the beginning of the Session the Council shall proceed to nominate a Chairman and Vice-Chairman, who, in the absence of the President, shall preside over Meetings of Council.

56. The Hon. Secretary shall be the executive officer of the Society, under the direction of the Council. He shall prepare the business for the Council and record the proceedings thereof. He shall collect all moneys due to the Society, and deposit the same subject to the order of the Treasurer. He shall personally certify the accuracy of bills or vouchers upon which money is to be paid, and shall draw and countersign all cheques, which shall be signed by the Treasurer. He shall have charge of the books and accounts of the Society, and shall furnish monthly to the Council a statement of receipts and expenditures and monthly balances. He shall prepare annually a report for the Council and from time to time shall furnish such statements as may be required. He shall conduct the correspondence of the Society, and keep full records of its proceedings. The Council may, on the recommendation of the Hon. Secretary, appoint a paid Secretary, who shall assist and be under the immediate direction of the Hon. Secretary and aid him in all matters.

57. The President shall, at the first meeting of the Council after his election, appoint, subject to the approval of the Council, the following standing committees: a Committee on Finance, of three members; a Committee on Papers, Editing, and Publication, of seven members representative, as far as possible, of the different interests. He may also arrange for temporary committees from time to time.

The President and the Hon. Secretary shall be ex officio Members of all Committees. The Hon. Secretary shall be the responsible editor of the transactions, and shall be assisted by an Editorial Committee; the editor of *The Illuminating Engineer*, the recognized official organ of the Society, shall be a member of the Editorial Committee.

PUBLICATION OF PROCEEDINGS, ETC., OF SOCIETY.

58. *The Illuminating Engineer*, published by the Illuminating Engineering Publishing Co. Ltd., in London, shall be the recognized official organ of the Society, and proceedings and announcements of the Society, etc., shall be published therein, subject to an agreement entered into between the Society and The Illuminating Engineering Publishing Co. Ltd.

59. Papers read or lectures delivered before the Society must not be published in full elsewhere than in the official organ of the Society, without special permission of the Council. Abstracts of lectures, papers, etc., must only be published after the actual date of reading or delivery.

FUNDS FOR RESEARCH, ETC.

60. The Council shall undertake, through the appropriate officers as directed elsewhere, the collection of moneys due to the Society, and shall also have power to receive donations for special purposes such as the prosecution of certain researches, etc., the organization and support of special courses of lectures on subjects connected with illumination, delivered either under the auspices of the Society or elsewhere as the Council may direct.

The ordinary funds of the Society, obtained by subscription, however, shall not be used to prosecute researches or for special purposes outside the recognized scope of expenditure of the Society without the sanction of the Members being duly obtained.

CO-OPERATION WITH OTHER INSTITUTIONS, ETC.

61. The Council shall be at liberty to approach or to entertain and, if desirable, accept overtures from other societies and institutions with a view to joint discussions of subjects of mutual interest, exchange of transactions, and co-operation to secure Government action, for the advancement of the objects of the Society.

POSSIBLE DISSOLUTION OF THE SOCIETY.

62. In the event of the Society being dissolved the available funds and property of the Society remaining after all liabilities have been settled shall be realized and divided equally between the existing Members at the date of dissolution, or applied to any other purpose that the Council may approve and a two-third majority of the Members at a General Meeting called for the purpose, may confirm.

By-laws

APPOINTMENT OF COMMITTEE, ETC.

1. The appointment of committees to report upon scientific and engineering subjects shall be authorized only by a majority vote of the Council, which shall be taken by letter-ballot. When such a committee is thus authorized, the President shall appoint the members thereof, subject to approval by vote of the Council.

ADMISSION AND EXPULSION OF MEMBERS.

2. An application for membership to the Society shall be made upon a printed form prepared by the Hon. Secretary, and approved by the Council, which shall call for such information as may be required by the Council to determine the eligibility of a candidate.

3. In the absence of replies from referees to inquiries for information, or if replies are not sufficiently explicit, the Council shall cause the applicant to be notified and shall hold his application in abeyance.

4. The privileges attaching to membership in the Society shall not be accorded to newly elected Members until they have paid their subscription for the current year. This by-law shall be printed upon the notification of election.

5. Upon receipt of an application for membership, which shall be made on the official form, the Hon. Secretary shall see that it has been properly filled up. If not, he shall return the form and notify the applicant of the deficiency. When an application is in proper form it shall be placed before the Council. The Hon. Secretary shall conduct for the Council the necessary correspondence with applicants and their referees.

FEES AND SUBSCRIPTIONS.

6. The annual subscription is payable in advance. Application for subscriptions shall be sent out quarterly by the Hon. Secretary.

7. If the subscription is not paid within one month after a Member has been notified of his election, he shall be communicated with; and if such fees are not paid within three months from the time of notification of election, the Council shall be free to consider the election void. This By-law shall be printed on the final notice above provided for.

8. From the annual fees paid by each Member 10s. 6d. shall be deducted and applied as a subscription to *The Illuminating Engineer*, the official organ of the Society, for the year covered by such payment.

9. Any Member whose subscription is six months in arrear, shall be informed of the fact by the Hon. Secretary and shall not receive its transactions or other publications until all amounts due are paid.

MANAGEMENT.

10. The Hon. Secretary shall, after each meeting of the Council, forward to each Member thereof a transcript of the minutes of the meeting, should the Council so desire.

11. Regular meetings of the Council shall be held the third Tuesday of each month, except when otherwise determined. Special Meetings of the Council or of the Executive Committees may be called by the President. Notice of such Special Meetings shall be forwarded to the Members of the Council or of the Executive Committee at least a week in advance of the Meeting. The notice shall contain a synopsis of the agenda to be brought before the Special Meeting, and no business other than that so specified shall be transacted at such a Meeting.

12. Should an Executive Committee have taken any action between Meetings of the Council, it shall report such action at the first Meeting of the Council following; if approved, the action of the Executive Committee shall be regarded as the action of the Council.

13. The accounts of the Hon. Secretary and Treasurer shall be audited annually prior to the Annual Meeting, by the Hon. Auditor or Auditors, as directed in Clause 43.

14. The Committee on Papers, and on Editing and Publication shall make such revision as may be considered necessary or desirable, of papers and communications offered for publication; in case of such revision the manuscript shall be returned to the author to obtain his consent thereto, and should such consent be refused, the acceptance or rejection of such a paper shall rest with the Council.

15. The Hon. Secretary and the Committee on Editing and Publication may, at their discretion, abridge or eliminate papers or reports of discussions for printing. The Committee shall cancel remarks that do not bear directly on the subject under discussion, or deal in personalities or are otherwise objectionable.

16. All papers, discussions and other matter intended for publication in *The Illuminating Engineer* shall, so far as possible, be revised and edited in manuscript and not in proof.

17. The Council shall have power to make due arrangements for the preparation of stenographic reports of proceedings at the Meetings of the Society, and provide payment therefor.

An Exhibition of Lighting

An Interesting Demonstration Arranged for The Academy in Rotterdam

By Dr.-Ing. N. A. HALBERTSMA

FIG. 1.—Showing "Sight" Demonstrations by means of 12 booths in a hexagonal rotunda.

CAN light, a most important medium for the success of any exhibition, be itself made the *object* of an exhibition? It might, perhaps, be feared that illumination could not make such a fascinating display as the domestic applications of electricity, nor arouse such an enthusiasm as a radio exhibition amongst the wireless amateurs.

In a certain measure this is true, for light is not as new and mysterious to the public as electricity and wireless. Light has been used by all of us from early childhood, and it is used daily, without further reflection, by millions. "Good Lighting," however, is still unknown to many of us because of the lack of a basis of comparison. If good lighting is shown, in comparison with bad lighting, to which not a few have become accustomed, the difference will not fail to make a profound impression and will stimulate an effort towards improvements. Hence the success of any lighting demonstration depends largely upon showing the contrast between "bad" and "good," and by letting the visitor recognize the bad lighting as the one he has been using for years.

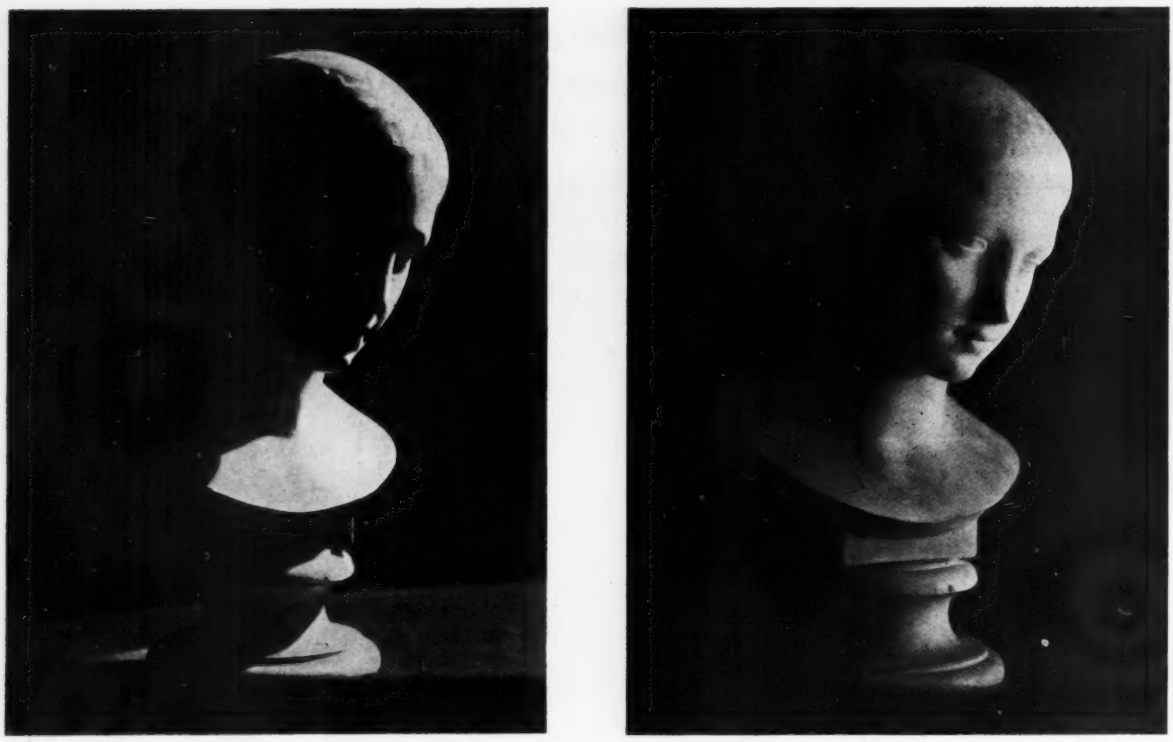
As a matter of fact, in all lighting demonstrations in this country (Holland), as well as abroad, the importance of such contrasting demonstrations has always been emphasized—following the slogan: "Seeing is believing"; at the same time efforts have been made to explain the principles of vision and the influence of light on vision. The primary purpose of illumination is seeing as quickly and as well as circumstances permit. For successful lighting, therefore, we should have a general idea of the functions of the eye, and of the way in which we see the objects around us.

This principle was kept in mind by the author when he was asked to organize a lighting exhibition at Rotterdam. In consequence this exhibition differed in certain respects from ordinary lighting demonstrations such as have been fully described in this journal. In view of this distinction a description of the exhibition may be of interest.

The Academy at Rotterdam, which is a School of Arts as well as of Technical Science, arranges an exhibition every year, in a hall of about 3,000 square feet, during the week between Christmas and New Year. Alternately water-colours, old furniture, ship models, architectural drawings, paintings, objects of applied art, etc., have been shown.

This year, searching for a subject which might interest both visitors with a technical inclination and those who prefer æsthetics, the Board of the Academy agreed to organize a lighting exhibition. The Academy succeeded in getting the support of the newly formed Dutch Illuminating Engineering Society, of the Museum of Labour, and of the Municipal Electrical Supply, whilst the author took upon himself the technical work connected with the organization of this exhibition, which was named "Sight and Light," the first and smaller part being devoted to sight, viz., the principles of seeing, whereas the second part contained the lighting demonstrations proper.

In order to facilitate the comparison between different kinds of lighting—usually to be considered as bad and good—two circuits (A B) were provided, which were alternately switched on by a motor-driven device of 5-kw. maximum switching capacity, 20 seconds being allotted to each of the two groups of lamps. All lamps



(*a*) Lighted by a clear-bulb gasfilled lamp. (*b*) Lighted by a similar lamp placed behind tracing paper.

FIG. 2.—Demonstrations of shadow.

burning continuously were connected to a third circuit, C, with a load of about 9 kw.

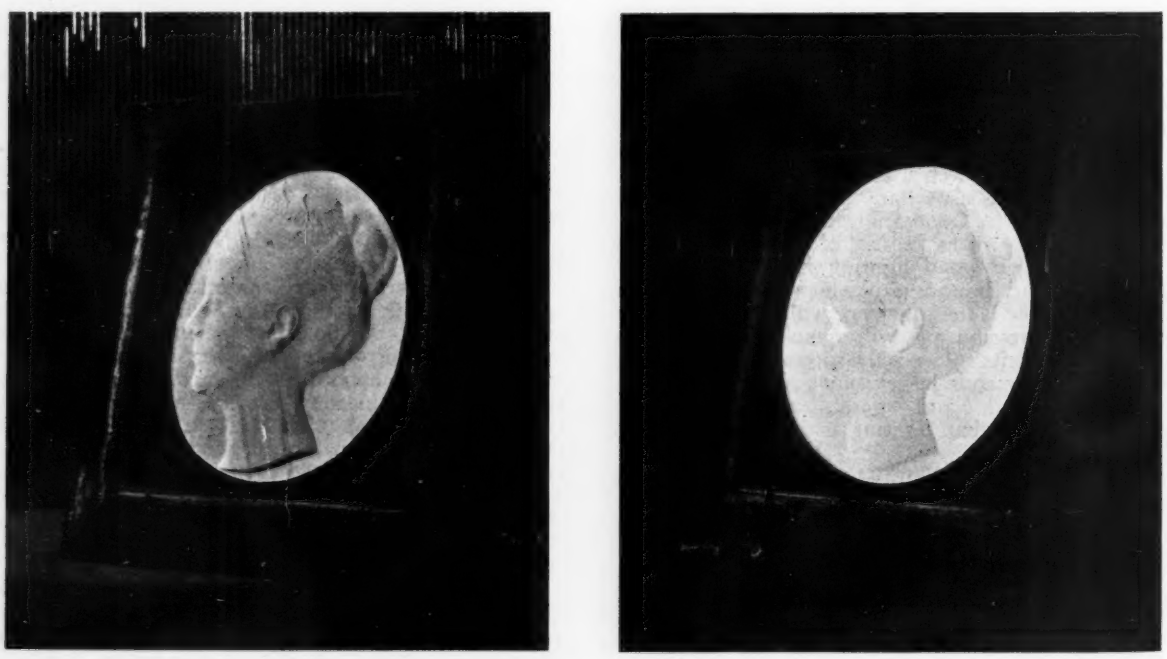
The demonstrations of "sight" were arranged in 12 booths, in a hexagonal rotunda (see Fig. 1). Two sides of the hexagon were taken up by the entrance and the exit, the four remaining sides containing three booths each. The four walls were devoted to the four fundamental phenomena on which sight depends, each being represented by three booths:

(A) *Contrasts of colour and* (*or*) *brightness*, as embodied in the surface of objects, and notably in plane surfaces (printed matter, handwriting, drawings, paintings, wallpaper, textile products).

Booth 1 contained a newspaper as an example of brightness contrast and a colour sketch as an example of contrast of colour, both being lighted continuously (circuit C).

Booth 2 contained a reading chart, partly printed on white, partly on grey paper. This chart showed the importance of big contrast, as it was much easier to read a certain size of type printed on white paper than the same type printed on grey paper. By alternately lighting this chart with 1 ft. candle and with 40 ft. candles (circuits A and B) a noticeable improvement of the reading power of small print was demonstrated.

Booth 3, a diary, partly printed in yellow and partly in black, showed the inferiority of the yellow type for reading, on account of lack of contrast. Alternate



(*a*) Lighted by a clear-bulb gasfilled lamp. (*b*) Lighted by a similar lamp placed behind tracing paper.

FIG. 3.—Appearance of bas-relief, showing importance of sharp shadow in this case.

(*a*) Lighted by a clear-bulb gasfilled lamp.

(*b*) Lighted by a similar lamp placed behind tracing paper.

FIG 4.—Appearance of highly polished objects.

lighting (circuit B) with blue light showed the yellow printed words, which were nearly invisible under ordinary light.

(B) *Shadows, as an aid in distinguishing the forms of bodies.*

Booth 4 contained a white plaster bust, which was alternately lighted by a clear gasfilled lamp and by a similar lamp behind a piece of tracing paper, acting as an artificial window and a light source of large dimensions (Fig. 2).

Booth 5, which was lighted by the same sources of light as booth 4, contained a bas-relief (Fig. 3) which, contrary to the bust, needed a sharp light to show details.

Booth 6 demonstrated the difference between single deep shadows and multiple shadows, caused by a group of light sources (circuits A and B).

(C) *Images of light sources and bright surroundings*, which are produced by reflection in the glossy surfaces of objects of metals, glass, pottery, etc., give relief and shape to such objects.

Booth 7 contained a collection of metallic objects of a more or less glossy character, ranging from old pewter to a highly polished silver vase. They were alternately illuminated by a bare lamp and a large surface source of light (as applied to booths 4 and 5), and presented the different aspects, as shown in Fig. 4.

Booth 8 contained a collection of glassware and pottery, lighted by circuits A and B, as in booth 7 (see Fig. 5).

Booth 9, with two lamps, one mounted high on the right-hand side and the other mounted low on the left-hand side, contained several objects which present beautiful surface reflection colours, when lighted in a certain direction (mother-of-pearl, butterflies).

(D) *Silhouettes, by means of which we distinguish persons and objects having a bright background.* This "seeing by silhouette" depends partially upon imagination and recollection.

Booth 10. A model of a subway in which the passers-by are clearly seen by their silhouettes

Booth 11. A model of a lighted street. Street lighting is generally known to depend on the appearing of persons and cars as silhouettes against the illuminated surface of the street and of the houses (Fig. 6).

Booth 12, a view of a factory or office building during the night, when all windows are shedding light, is also a typical case of seeing by silhouette.

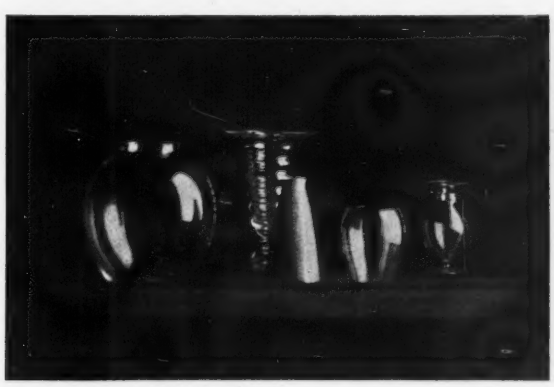
In addition to this introductory section the lighting exhibition at Rotterdam contained others subdivided into the following divisions:—

(1) *Lamps*, historical and modern, with a short summary of the manufacture of the incandescent lamp.

(2) *Fixtures and Luminaires.* Space in such non-commercial exhibitions generally does not permit of a complete collection of the many types of suitable fixtures and luminaires which are on the market. Hence a selection of typical fixtures only was shown, starting with enamelled and opal reflectors, both obsolete and modern. Three dining-room luminaires (Fig. 7) show the difference between a silk shade without lining (on the left hand of Fig 7), a similar shade with white silk lining (in the centre), and a shade with white silk diffusing cover (right-hand fixture). The sharp, coloured shadows under the left-hand fixture without lining were as noticeable as the shadowless diffused light of the fixture on the right hand.

Further fixtures included a one-piece opal glass unit, a Holophane-filterlite unit, the Duplexalite and some typical pieces of glass, which had been pressed in moulds

(*a*) Lighted by a clear-bulb gasfilled lamp.



(*b*) Lighted by a similar lamp placed behind tracing paper.

FIG. 5.—Appearance of Glassware and Pottery.

FIG. 6.—Showing "silhouette effect" in a lighted street.

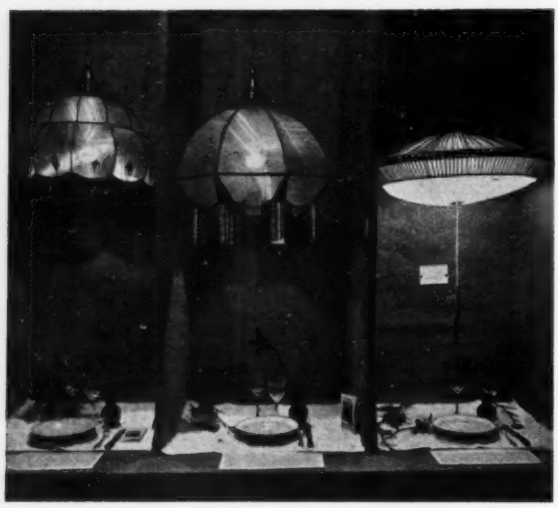
and frosted afterwards. These may be said to represent the modern French luminaire style, which was displayed with such remarkable results at the Paris Exhibition of Aplied Arts of 1925. Lalique, Sabino Genet and Michon may be considered as some of the most prominent artists in this field.

In a similar way the collection of portable lamps and bracket lights included old and obsolete types as well as the most modern products of the Paris School (Perzel, Cheuret) (Fig. 8).

(3) The applications of light also played a large part at this exhibition (see the plan, Fig. 9). Special demonstrations were given of

(*a*) Show-window lighting.

(*b*) Mirror lighting.



(*a*) (*b*) (*c*)

FIG. 7.—Showing comparative effect of three dining-room fittings, (*a*) without lining, (*b*) with white silk lining, and (*c*) with white silk diffusing cover.

FIG. 8.—Collection of Portable and Bracket Lights, including specimens of products of the Paris School.

(*c*) Kitchen lighting.

(*b* and *c* are shown in Figs. 10 and 11.)

(*d*) Writing-desk lighting.

(*e*) Typewriter lighting.

(for *d* and *e* see Fig. 12.)

(*f*) Sewing-machine lighting.

A special division of the exhibition was also devoted to traffic lighting. This included photographs and maps of coast lighting, traffic signals, lighting systems for landing fields, etc. Harbour lights, electric ship lanterns, road signals, and a 20,000-watt (50,000 candle-power) lighthouse lamp, as manufactured by the Philips Co. for the French Coast Lighting Service, and the marvellous non-luminous safety reflectors (Cataphotes) were also shown.

Although different phases of home lighting had also been presented under separate headings at the exhibition, (e.g., mirror lighting, kitchen lighting and desk lighting), a résumé of home lighting was given as the final feature of this exhibition. In the home light is used by everybody, and as everybody is free to select his own lighting arrangements according to taste, it may be expected that any lesson, which was learned at the exhibition, would find its first practical application in the home itself.

For this reason stress was laid on well-known slogans in every part of the exhibition:

"When writing, have the light on your left side."

"Have the lights well placed in the kitchen, where the work is done."

"A central lamp above a mirror can never give suitable light for shaving."

"Use only table lamps with a large lighting field."

"Bright surroundings improve both the quantity and the quality of illumination."

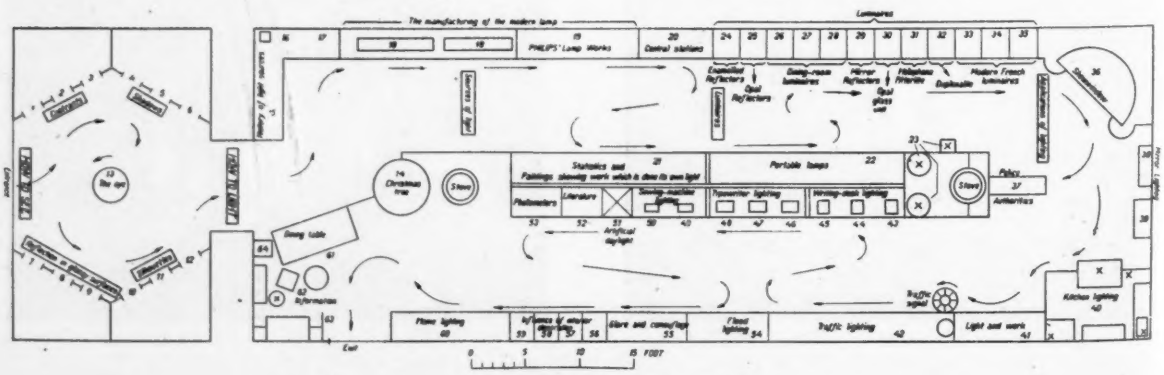


FIG. 9.—General Plan of Exhibition.

FIG. 10.

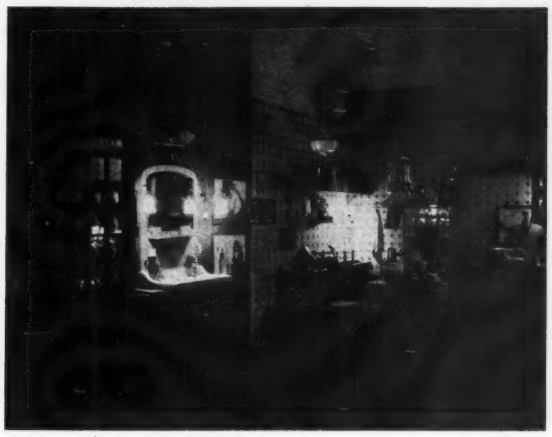


FIG. 11.

Examples of Kitchen Lighting.

The home-lighting division proper contained a beautiful collection of photographs and drawings of the typical defects of home lighting, and how they can be avoided.

There was, however, added to this, a group of demonstrations which could be described under the heading "camouflage." Camouflage, which has been developed to such a high perfection during the war for military and naval purposes, may be regarded as a science which is intimately related to Illuminating Engineering. Yet in a sense, it is the opposite of Illuminating Engineering. There are various effects (whether depending on contrast of colour, shade, silhouette, reflection), which, if cleverly used, can improve seeing conditions; but these are used by the art of camouflage to *disguise* objects and persons and to *deceive* the observer.

Unconsciously, we very often, in furnishing and decorating our homes, act more in the way of camouflage than with the effect of distinguishing objects. A carpet on the floor, or a cover on the table with a composite pattern, with strong colours, and even with black and white patches, forms a background on which objects, dropped on to the floor, can hardly be seen at all, or can only be distinguished if the light strikes them at a very definite angle. A piece of wallpaper with a flower pattern with dark patches entirely camouflaged a flush-mounted switch. Visitors were requested to note the time they needed for finding on a coloured table cover seven small objects—if they found them at all!

These cases of camouflage in the ordinary home may be looked at as special "stunts," for amusing visitors, but, in the author's opinion, their importance in this lighting demonstration went much deeper. They proved that, as good lighting is not only obtained by sound engineering principles, but is also an art, one cannot obtain the best results by considering the lighting scheme alone. The surroundings should also contribute to the success of the illumination.

Within 7 days, from 10 a.m. to 4 p.m., 8,000 visitors passed through this lighting demonstration. Apart from this general education the representatives of the Dutch Illuminating Engineering Society, who were present, came in touch with many architects, engineers, decorators, electricians, etc., to whom more detailed information was given on good illumination and methods of obtaining it.

FIG. 12.—Portable Office Lamps and Typewriter Fittings.

The Science Library, South Kensington

Attention may be drawn to the exceptional resources of the library associated with the Science Museum, South Kensington. The library at the present time contains 165,000 volumes, and these are increasing at the rate of 9,000 a year. The total number of periodicals is about 8,000. This library contains many books and periodicals which have hitherto been readily available only to those resident in London; and for many of these the use of books in a reference library has been inconvenient and wasteful of time. The Board have therefore authorized the issue of books and periodicals on loan to scientific workers through approved institutions, on the condition that no charge for postage or replacement of lost copies falls on public funds. Books will thus be forwarded to the institution to which an applicant belongs, and which will guarantee the replacement of any book lost or damaged. Requisitions in duplicate on forms obtainable from the library. A list of scientific periodicals in the library has just been published, and can be obtained from the Science Museum, H.M. Stationery Office, or any bookseller.

A Key to Specialized Information

Just as the practical utility of a book is impaired by the want of an index, so the vast aggregation of knowledge built up is apt to be lost owing to the lack of a master key as to its whereabouts. Throughout the country there are numerous centres of specialized knowledge, the existence of which has only to be known for them to prove of the greatest service to the world. It is with the object of bringing these to light and recording their salient features in concise form that the Association of Special Libraries and Information Bureaux is compiling a Directory under the editorship of Mr. G. F. Barwick, late Keeper of Printed Books at the British Museum.

At a meeting held at the Royal Institute of British Architects on February 23rd, Mr. Barwick described the present position of this work, which has now been in progress for eight months. It has been decided to go forward with the first edition of the Directory at midsummer this year, but much still remains to be done. It would help considerably if any libraries, organizations, firms, and individuals which have special information on any subject, and which have not yet been in touch with the Editor, would communicate with him at the earliest moment. The address of the Association is 38, Bloomsbury Square, London, W.C.1.

Some Notes on The Seventeenth Annual Exhibition of Scientific Apparatus

(Arranged jointly by the Physical Society and the Optical Society at the Imperial College of Science and Technology, South Kensington, January 4th-6th, 1927)

THE combined exhibit of electrical, optical and other physical apparatus, arranged by the Physical and Optical Societies during January 4th—6th, proved, as usual, to include many items of interest in connection with illumination. The section which naturally attracted first attention was that dealing with research. Here many varied forms of apparatus were shown. The British Photographic Research Association displayed an improved form of photo-electric photometer, which is used for testing the opacity of photographic negatives. The selenium cell used in the original apparatus is now replaced by a special gasfilled photo-electric cell, constructed by Mr. T. C. Keeley, of the Clarendon Laboratory, Oxford. Current is magnified by a valve and recorded by a galvanometer which is very dead-beat and quick in action. Other exhibits by this association illustrated the structure of the photographic image.

The exhibit of the Research Laboratories of the General Electric Co. Ltd. also contained specimens showing three stages in the making of the flat annular photo-electric cell. Another interesting feature of this exhibit was the machine enabling the voltage rating of electric lamps to be determined automatically and rapidly by the aid of two photo-electric cells. The method is based on colour-matching, the two cells being so prepared that one is more sensitive to red light and the other to blue. It is stated that vacuum lamps can be thus rated with a mean error of 0.13 per cent. in voltage and at the rate of about 200 per hour. The process only involves observation of the pointer of a galvanometer and no photometric comparison, and was shown in operation, the series of lamps being apparently dealt with very expeditiously.

The display of the British Research Association for the Woollen and Worsted Industries contained an exhibit of colour-fading of materials, on lines similar to those adopted at the optical convention. The effect of sunlight in fading a wide range of colours was shown and the important part played by humidity illustrated. A fascinating item in this exhibit was the small cabinet receiving ultra-violet light from a small quartz-tube mercury-vapour lamp, filtered through Chance's glass. Many objects placed within the chamber fluoresce. This can even be seen by the appearance of the skin and nails when one inserts one's hand. The effect has doubtless many possible applications in the textile industry, as illustrated by the exhibit of two pieces of white cloth, one partially mildewed. In ordinary light the mildewed spots were imperceptible, but under the ultra-violet light they could easily be seen.

Photometry was again represented in the Sector Polar Distribution Photometer exhibited by the G.E.C. Research Laboratory, intended to facilitate the rapid determination of polar curves of light distribution. A Lummer-Brodhun contrast head is used, and the brightness of the comparison field is controlled by a stationary variable sector and rotating prisms. In addition, the observer can manipulate the mirrors so as to obtain light from different directions in turn, and by means of a periscope can observe the angle at which rays are received. One observer can therefore make all the necessary measurements and adjustments without leaving his seat. Another exhibit of the same firm was devoted to the structure of opal glass. Photographs and X-ray patterns show the nature of the particles giving rise to different effects. By means of two solutions with white matter in suspension the influence of the size of the particles was illustrated. With very small particles one can see the filament as a red line, surrounded by a white halo; with larger particles the diffusion is complete, no filament being visible.

The British Thomson-Houston Co. Ltd. (Engineering Laboratory) had on view an ingenious apparatus for measuring the flicker of lamps on alternating-current circuits, and a pleasing little apparatus showing how a luminous discharge can be produced following the liberation of a dose of tungsten vapour in an argon tube.

The National Physical Laboratory had a considerable number of exhibits, including the model-room for determining the effect of window dimensions, interior decoration, etc., on the natural lighting in a proposed building. The model is about one-twelfth scale, and predeterminations can be readily made with a portable photometer.

The Research Department of Metropolitan Vickers Electrical Co. Ltd. included in their exhibit specimens of various rare metals and, in particular, samples of chromium plating, which gives a very hard and non-tarnishable deposit which has proved very useful for various forms of reflectors.

In the above account we have selected for mention those exhibits bearing most closely on illumination and photometry, but there were many others of great scientific interest. The exhibits of the Admiralty Research Laboratory and the Air Defence Experimental Establishment attracted a considerable amount of attention, the sound-locating apparatus in the latter display being particularly interesting.

The display in the remainder of the exhibition, as usual, contained a very comprehensive collection of optical apparatus. Messrs. R. & J. Beck Ltd., Chas. Baker, and other firms showed microscopes in great variety, and the first-named made a special feature of supplementary illuminating devices, such as "Pointolite" and "Intensity" lamps. The Cambridge Scientific Instrument Co. Ltd., in addition to many forms of pyrometers and recording instruments, showed a portable photometer, originally devised for the purpose of comparing the whiteness of various powders. Actinotherapeutic apparatus was shown by Messrs. The Cox-Cavendish Electrical Co., new features being a portable carbon arc lamp for home use or microscope illumination, and a new "photometer" devised by Dr. F. W. Alexander for testing the intensity of ultra-violet rays. The exhibit of Everett, Edgcumbe & Co. Ltd. was mainly electrical, but one was interested to notice a specimen of the compact cubical box integrating photometer, and also the new and improved model of the luxometer which has been redesigned in order to comply with the B.E.S.A. specification. The inclusion of the battery, rheostat and controlling voltmeter within a single case has made this a very compact little instrument.

Considerable interest was taken in the epidiascopes shown by C. Garner, Ogilvy & Co. and others. This instrument has been considerably improved during recent years, and forms very suitable for use in schools were shown. The convenience of being able to project an image of a solid object or a picture, without making a lantern slide, is obvious. The degree of illumination obtained with a 500-watt gasfilled lamp is very much greater than might be expected, and enables the image to be quite clearly seen in a darkened room.

Another very comprehensive exhibit was that of Messrs. Adam Hilger Ltd. There was a fine display of spectroscopic apparatus. Perhaps the two most interesting instruments were the Hilger-Nutting spectrophotometer and the Guild trichromatic colorimeter, the latter a simple form of apparatus which should be very useful to industries concerned with research on colour.

POPULAR & TRADE SECTION

COMPRISING

Installation Topics—Hygiene and Safety—Data for Contractors—Hints to Consumers

(The matter in this section does not form part of the official Transactions of the Illuminating Engineering Society; and is based on outside contributions.)

The Magnitude of the Lighting Business

MEMBERS of the electrical industry who, from day to day, are intimately concerned with engineering problems, are sometimes inclined to forget the rapid progress which has been made in the development and application of electrical apparatus in recent years. This is particularly true of lighting. It is only a matter of some 15 years ago that the carbon filament lamp was the most efficient electrical illuminant available to the public. As a result of scientific research, the metallised carbon lamp, the tantalum lamp, the squirted tungsten lamp, the drawn-wire tungsten lamp, and the gas-filled lamp, have followed each other in rapid sequence. Each development followed so quickly on its predecessor that the correct application of the newer lamp has not kept pace with the development of the light source itself. Consequently, there are to-day millions of the modern gas-filled lamps used in conjunction with the primitive equipment designed for the carbon lamp, or, worse still, used without any reflecting or diffusing equipment at all.

Nevertheless, side by side with lamp development, the design of lighting equipment has been steadily improved to suit the new conditions, and, although there are a number of good lighting installations of exceptional merit, these form but a small minority compared with the bad lighting installations which are to be seen in all classes of lighting service. It is the misuse of the gas-filled lamp that is responsible for the statements frequently made by the public that "Too much electric light is bad for the eyes."

Now this glare from exposed lamps is a brake on electric light development, for it can be proved conclusively that industry and commerce require higher standards of illumination than at present exist. Our industry, however, cannot satisfy this need of the community until it has educated people to use light properly. Repeated emphasis must be laid on the difference between "raw" light and effective illumination.

There are many engaged in industry to-day who still regard artificial lighting either as an expensive luxury to be employed sparingly or else as a necessary evil to be borne with grudging patience like a bad debt. Yet, as all intimate with the production of electric light to-day know, this is one of the most productive, and, at the same time, cheapest tools in industry, and a prime necessity in an efficient commercial organization.

Furthermore, development of lighting automatically develops all other important sections of the industry, from lamps to turbines, and it does not need the services of a mathematician to calculate the enormous effect which would be produced by merely doubling the present intensities of illumination. Yet even doubling would be far below the standards which could be recommended on a strictly economic basis, so that the potentialities are almost unbounded. At the moment it is impossible for us to conceive saturation point, since, unlike other forms of electrical service, such as power and heating, which have a fixed value installed, there would appear to be no limit until something approaching daylight values of lighting are reached.

It is found from experience that, once the public have the facts clearly before them, they are not backward in accepting recommendations, and, in many cases, having discovered for themselves the value of good lighting, these recommendations are exceeded. Hence it will be seen that the market is a constantly expanding one, and our recommendations of to-day will undoubtedly be obsolete in the years to come. The surest and most convincing means of education is an actual demonstration of lighting effects, such as was witnessed during this Illumination Design Course arranged by the E.L.M.A. Lighting Service Bureau.

Estimates.

Estimates which at present imply saturation point may, owing to improved knowledge on the part of the lighting industry and better appreciation on the part of the public, prove to be merely the starting point of a new development.

The following series of estimates covers the five principal fields of lighting: Factories, offices, shops, public buildings and the home. In each case the numbers have been obtained from directories, and are, we believe, sufficiently accurate for the purpose in view. In each case also the cost has been estimated of modernizing existing electric lighting installations and of wiring and equipping in accordance with recommended lighting practice all buildings not at present electrically lighted.

In considering the figures, it should be remembered that each unit is assumed to be a separate installation. For example, a factory may be either a single workshop or an establishment employing several thousand employees. The estimated cost of £100 for modernizing the equipment, although high for the former type would be low for the latter. We consider our estimates are made on a conservative basis, yet the possibilities for business development they reveal are sufficiently striking.

The estimates are taken from a paper read by Mr. C. W. Sully at the First World Power Conference:

Estimated cost of equipment for Factories and Workshops (265,500)	£38,825,000
Estimated cost of equipment for Offices (758,650)	37,932,000
Estimated cost of equipment for Shops and Stores (574,360)	35,360,000
Estimated cost of equipment for Public Buildings (86,870)	20,880,000
Estimated cost of equipment for Homes (9,440,000)	257,320,000
Grand Total ...	£390,317,000

These figures take no account of the annual revenue to be derived from the sale of energy or of the business to be done in providing additional generating equipment, switchgear, cables, and the numerous mechanical devices such as automatic stokers, coal conveyers, etc., which form an integral part of the modern generating station.

This figure of nearly £400,000,000 represents the amount of business awaiting immediate development, and is a sufficient prize to demand the united efforts of our industry.

The Effect of Super-Imposed Coloured Light on Pictures in Kinema Theatres

In the last issue of *The Illuminating Engineer* a brief account was given of the recent demonstration at the showrooms of Holophane Ltd. of the uses of coloured light in kinema theatres.

The writer has since had an opportunity of studying some of these effects, notably the use of the "Duo-Phantom" equipment, to superimpose coloured light on the ordinary black and white picture on the screen. The idea of *superimposing* the coloured light by means of an apparatus quite distinct from the projector is something new. One can, of course, readily produce colour on the screen by inserting tinted glasses or gelatines in the path of rays from the projector. But it is evident that the flexibility of this arrangement is very limited. One cannot gradually alter the intensity of the light, nor the nature of the colour, and in general any tint adopted would persist through a certain scene, or at least if a change is made it would be abrupt.

With the "Duo-Phantom" device extraneous coloured light is directed on to the screen from a series of coloured lamps concealed in a batten at the foot of the screen. As lamps of varying colours, controlled by a rheostat, are used, the intensity and mingling of colours can be controlled at will. Whilst the film is being shown the tint can be gradually altered so as to assist the emotional appeal; for example, blue or violet light being used in a sad scene, and red or orange for one that is cheerful and stimulating. By combining the various lamps almost any desired shade of colour can be obtained.

The question that is at once raised by an expert, however, is "What is the effect of the superimposing of coloured light on the *contrast*?" When the adoption of weak diffused general illumination in a theatre during the showing of a film was first suggested showmen were apprehensive that stray light falling on the screen would impair the appearance of the picture. This fear has proved groundless. Provided the supplementary general lighting is skilfully arranged the picture need not suffer. The amount of stray light actually reaching the screen can be reduced to a negligible amount; at the same time the general illumination, feeble though it may be, is of considerable assistance to attendants in showing people into their seats, and possibly also beneficial to the eyes of the spectators in diminishing the extreme contrast between the brightness of the picture and the surrounding darkness.

It is, however, going a step further to deliberately direct light, other than that emerging from the projector, on to the screen. This point was discussed at some length by the writer with Mr. Williams, in the Holophane Laboratory. Naturally, the success of this effect depends on the skilful manipulation of the apparatus. The superimposed illumination must be low in comparison with that produced by the film-projector. Evidently the picture would be "killed" if the screen was flooded with bright extraneous light. But the demonstration did not suggest that the contrast between high lights and dark regions on the film was unduly diminished.

The general effect is somewhat softer, and it is claimed that the addition of the colour tends to give "depth" to the picture, besides its psychological value. The idea was suggested that in a black-and-white film, as ordinarily shown, the contrasts in brightness are excessive, and greater than those in nature; and that in most cases the smoothing down of such contrasts is a positive benefit in rendering the effect on the eyes less trying. This is a point that seems to deserve scientific study by kinematograph experts. It is quite possible that the contrasts in many films are too great—for the possibilities of a projection apparatus in this direction are much greater than those in nature. In a natural scene one would imagine that the relative brightness of the contrast between the brightest and darkest object would be mainly settled by their reflecting powers (excluding extreme cases in which views of the sky, brilliant local lighting by sunlight, etc., appear), and would thus not exceed about 30 to 1. In a film where the darkest portions may have zero brightness the contrast must often be very much greater than this.

Another feature of the "Duo-Phantom" arrangement is that it permits the formation of a coloured luminous border to the actual picture. This might also be a physiological advantage in diminishing the abrupt contrast in brightness of the screen and its surroundings.

Observations of Light Emitted by Plants and Animals

Of late years much interest has been taken by scientists in the light emitted from various phosphorescent substances and luminous organisms, a feature of which is the production of "cold light," presumably in a highly efficient basis.

One of the most recent investigations is summarized by W. W. Coblentz and C. W. Hughes in a paper issued by the Bureau of Standards (Washington). The objects examined included decaying wood, crustacea, fireflies, and phosphorescent minerals, such as zinc sulphide. One of the chief objects was the determination of the distribution of energy throughout the spectrum. In view of the faintness of the light this had to be examined by an indirect method. The luminous object was placed in front of a spectrometer and the image photographed on Wratten panchromatic plates. The distribution of energy could then be deduced by a knowledge of the characteristic curve of the plate.

This method naturally required much patience and prolonged exposures. For the crustacean material an exposure of one hour sufficed, but for the "fox fire" yielded by decaying wood from 30 to 70 hours was necessary, the material being meanwhile renewed at intervals. Some interesting points in connection with the emission of light are noted. For the phosphorescence of the wood the presence of moisture and oxygen is necessary. Jars of material, when sealed up, ceased to glow after several hours. Yet the amount of oxygen necessary is very small; placing the material in a jar of pure oxygen instead of air had no appreciable influence on the brightness. Similar exposure to sunlight and ultra-violet rays produced no greater luminosity.

In the original paper curves showing the distribution of energy for each material are presented. The spectral energy of the luminous fungus *Agaricus melleus* is unsymmetrical, extending from .43μ to 0.67μ, with an intense emission maximum at 0.52μ and probably a weak maximum at 0.58μ. The curve for the luminescent crustacea *Cypridina* is symmetrical, extending from 0.41μ to 0.62μ, with a maximum at 0.48μ in the blue-green. The curve for the firefly is also unsymmetrical, extending from 0.50μ to 0.68μ, with a maximum near 0.565μ, thus verifying previous observations. Zinc sulphide gives a maximum at 0.52μ in the blue-green, and another variety, yielding apparently orange-coloured light, was found to have two emission maxima, one at the same point (0.52μ), with a more intense maximum at 0.61μ, the latter being responsible for the orange colour of the light as a whole.

The whole question of the nature of the light emitted from various organisms, insects and fungi is a most fascinating one. The chief feature of the radiation in all cases so far examined is the very small amount of radiant heat emitted, and it may be that researches in this field will lead to the evolution of new and efficient light sources in the future.

The British Thomson-Houston Co., Ltd., Crown House, Aldwych, London, W.C.2.

FIG. 1.—The General Assembly Hall (Boys' Department) at Crockett's Lane Elementary School is 67 feet long by 31 feet wide, and is illuminated by three 12-light Sugg "Westgate" gas lamps and two 6-light "Bon Marché" lamps. The balconies are lighted by four 3-light burners. All lights are controlled by distance switches. The hall is extensively used for dances and other social functions throughout the winter months, and the new gas lighting has met with general approval.

School Lighting at Smethwick

A Step in the Right Direction

THE decision of the Education Committee of the County Borough of Smethwick to bring their school lighting up to date has resulted in some installations upon which they have every cause to be congratulated.

During the past six years the lighting has been periodically revised. Flat-flame burners were replaced by "Kern" and "C" upright gas burners, and later an installation of universal angle burners was provided. Throughout these changes, however, no variations were apparently made in the number or the positions of the lighting "points," with the result that the illumination of the schools was by no means perfect. The matter has recently, however, received full and detailed consideration, with the result that the Engineer of the Gas Department at Smethwick has now been able to provide a complete gas lighting scheme which embraces a redistribution of points based upon scientific principles.

The whole of the elementary schools in the Borough, at which over 12,000 children are educated, have been brought into the scheme, and comprise the following:

Slough Lane	...	Mixed and infants.
Oldbury Road	...	Boys, girls and infants.
Brasshouse Lane	...	Boys, girls, junior boys and girls and infants.
Corbett Street	...	Boys, girls and infants.
Bearwood Road	...	Boys, girls and infants.
Crockett's Lane	...	Boys, girls, infant boys and infant girls.
Cape Schools	...	Boys, girls and infants.
Smethwick Hall	...	Boys, girls and juniors.
Victoria Special School		

COUNTY BOROUGH OF SMETHWICK EDUCATION COMMITTEE.
215, High Street, Smethwick.
11th February, 1927.

The Gas Engineer and Manager,
Gas Works,
Rabone Lane,
Smethwick.

Dear Sir,

Artificial Lighting in Elementary Schools.

The Building Minor Sub-Committee of the Education Committee recently made an inspection of the Elementary Schools which have been relighted by your Department, and I have great pleasure in informing you that the members were highly pleased with the results. The present lighting shows a vast improvement over the previous state of affairs, and gives every indication that it will be entirely satisfactory. Since this visit I have discussed the lighting with certain of the Committee's Head Teachers, and they also are very pleased with the improved position. The Head Teachers of the Evening Schools inform me to the same effect.

Yours faithfully,
DIRECTOR OF EDUCATION.

A New 2,000 Gas Lamp Scheme.—In all, some 2,000 new gas lamps and fittings of different designs and candle-powers have been provided to meet the varied requirements. Most of these fittings are Sugg's "Surbiton" lamps in 2, 3 and 4-light sizes. These are, in fact, provided in all of the classrooms. They have highly efficient super-heated cluster burners, and are fitted with milk-white silica globes of the open type which ensure a well-diffused light devoid of glare. The lamps have aluminium casings which reduce the possibility of discolouration to a minimum. The upturned reflectors provide an angle of distribution which ensures that while the bulk of the light is thrown down on to the desks, the upper parts of the rooms are also particularly well lighted. The lamps have been found from experience to entail very low maintenance costs.

Classroom Lighting by Gas.—A typical classroom in one of the schools at Smethwick measures 24 feet by 22 feet, and in the new scheme is equipped with five 2-light lamps, each consuming $5\frac{1}{2}$ cubic feet of gas per hour. Illumination tests taken show that a minimum illumination of 4 foot-candles is provided on a standard white surface placed on the desks, while the maximum illumination reaches 7.2 foot-candles. The previous system of lighting, consisting of five universal angle burners, gave a much lower standard of illumination, with a gas consumption approximately equal to that of the new lamps.

A Well-lighted Woodworking Centre.—Another room dealt with is a woodworking centre. This is a sub-basement room, 61 feet long by 24 feet wide. It is now lighted by nine 3-light "Surbiton" lamps, each con-

FIG. 2.—This classroom in Smethwick Hall Junior Elementary School is 23 feet long by 20 feet wide, and accommodates 40 children between 5 and 8 years of age. It is lighted by four 2-light "Surbiton" gas lamps with silica globes.

FIG. 3.—Smethwick Hall Manual Instruction Centre. Every week 400 day boys receive instruction in this room. The room is also used on two evenings a week by youths who have left school. It is lighted by nine 3-light super-heated gas lamps.

suming 8¼ cubic feet of gas per hour. The previous lighting installation consisted of eighteen universal angle burners, consuming more gas than the new lamps and providing an illumination which was by no means adequate for work of the kind carried out in the room.

The Science Laboratory.—A room used for chemistry and physics, and measuring 24 feet by 24 feet, is fitted with six 3-light "Surbiton" lamps. Illumination tests in this room gives minimum and maximum illuminations of 5 and 12.2 foot-candles respectively on bench level.

Heat from Gas Burners Appreciated by Pupils.—An interesting point in connection with these installations, and one which should never be lost sight of by school authorities, is the pleasant warmth imparted to the room by the gas burners, for artificial lighting is mainly required during the cold dull months. In the typical classroom, referred to above, the five gas lamps give out no less than 12,000 B.Th.U.'s per hour, thus adding appreciably to the comfort of the students. In the woodworking centre, already described, the amount of heat given out by the lamps amounts to 33,000 B.Th.U.'s per hour, not only helping to warm the room, but to keep the stocks of wood and tools in good condition.

On completion of the lighting installations, the Education Committee made an inspection of them, and while expressing their entire satisfaction at the amount and quality of the light provided, commented specially on the genial atmosphere created by the heat radiated from the lamps.

FIG. 4.—The Clinic and Welfare Centre at Smethwick Hall Elementary School, in which, during 1926, over 8,000 children were examined by doctors, and 500 children received eye-treatment. It is lighted by two 2-light "Surbiton" lamps, and has a special gas burner for illuminating the eye-testing card. A geyser provides an instantaneous supply of hot water.

Staircase Lighting. — Difficulty has frequently been experienced in the lighting of school staircases. At Smethwick this has now been overcome effectively by the use of Sugg's aluminium back lamps of the "port-hole" type, fitted with secret key fastenings. The outside stairways are lighted by Sugg's "Littleton" lamps arranged with distance-control devices which enable the caretakers or other responsible servants to turn them on and off from points inside the building.

The Importance of Good Lighting in Schools.—Smethwick Education Authorities have not been long behind London and other large towns in bringing their school lighting by

FIG. 5.—A typical example of main corridor lighting at Smethwick Hall School. The corridor is 160 feet long, and is lighted by 10 super-heated gas burners with silica globes.

FIG. 6.—A Staircase lighted by a 1-light gas wall lamp so placed that it lights up two flights of stairs. Further details of this light are given in the accompanying article.

gas up to a high state of efficiency. They have undoubtedly taken a step in the right direction, for the care of the eyesight of the rising generation is a matter which deserves the fullest possible consideration. A glance at the copy of a letter (reproduced on page 84) sent by the Smethwick Education Committee to the Gas Engineer at Smethwick leaves no doubt as to the improvements which can be so easily effected in schools by the use of modern gas lamps of the correct type and candle-power properly distributed on lines advocated by illuminating engineers.

Smoke Abatement.—One of the ideals of the Smethwick Education Authorities is to ensure not only good artificial lighting in their schools, but a smoke-free atmosphere which will permit of the maximum possible sunshine reaching the town and the schools. In this connection it is of interest to note that the Education Authorities have had their domestic science centres equipped with modern smokeless labour-saving gas-cooking, water-heating and ironing appliances of the type which they hope the children will use in later life, and that they have also recently given an order for the substitution of over fifty gas fires for coal fires in the staff rooms of the whole of the schools in the Borough.

FIG. 7.—The Physical Instruction Room at Smethwick Hall Junior Elementary School is 35 feet long by 22 feet wide and is used for physical drill and folk dancing, also as a general assembly room. It is lighted by four 4-light superheated gas lamps

FIG. 8.—Two Hundred Students, aged from 14 to 16 years, receive instruction in Crockett's Lane Manual Instruction Centre, Smethwick, every week. The room is 31 feet long by 21 feet 7 inches wide and is lighted by four 4-light gas lamps with No. 2 inverted burners and silica globes.

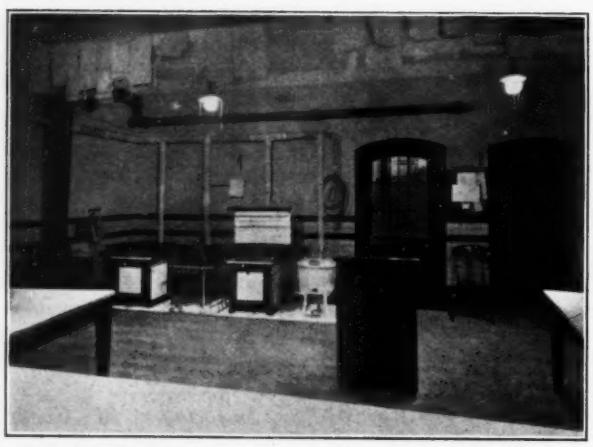


FIG. 9.—Brasshouse Lane Domestic Science Centre is lighted by gas and is equipped with two modern gas cookers, a gas wash copper and a large gas stove for heating irons. Two hundred students receive practical training in this room every week.

FIG. 10.—The Science Room (for scholars aged from 12 to 14 years) at Waterloo Road Elementary School, Smethwick, is 24 feet square. The six 3-light gas lamps give minimum and maximum illuminations on bench level of 5 and 12.2 foot-candles.

FIG. 11.—The Cookery and Laundry Instruction Room of the Holly Lodge High School for Girls has accommodation for 18 students and is equipped with two gas cookers, several gas hot-plates (sunk into benches), four gas irons and one gas copper. All cooking in the school canteen is done by gas.

FIG. 12.—Another view of the Cookery and Laundry Instruction Room, to be seen in Fig. 11, showing the gas cookers and gas wash copper. The students of this school are wisely taught to use the modern types of smokeless labour-saving appliances with which, later on, their own homes will be equipped.

Illumination as a Production Factor

By J. FORBES MARSDEN

JUDGING by the appearance of the windows and lighting fixtures in the average factory, it is fairly obvious that those in charge are unaware of the value of good illumination as a production factor. Windows are frequently so thickly coated with grime inside and outside that one would have thought sheer shame alone would have caused the management to have had them cleaned. Surely in most factories a labourer could be spared to keep the windows cleaned. In any event, window cleaners are to be found in most towns, and the expense is almost negligible compared with the results obtainable.

Apart altogether from the extra safety to employers from accidents caused by poor illumination, there remain the questions of the health and comfort of the worker, the reduction of eye fatigue with its attendant loss of quality and quantity of product.

Most people feel greater joy in mere existence on a bright sunny day than on a dark dismal one; and in consequence there is a feeling also that one can accomplish more. Precisely the same thing occurs in an office. Where this is lighted by small windows not regularly cleaned, not only does the room tend to depress one, but dirt inevitably lurks in all the corners. Contrast this with the office having large windows kept regularly clean, the whole place is cheery and bright, the interior is usually clean because the extra illumination shows up any dirt that may have been left in corners. Because windows have been mentioned it must not be concluded that the same arguments do not hold good for artificial light. As a matter of fact, the arguments for good artificial illumination are even stronger than for good natural illumination. Good natural light costs nothing, but artificial light costs money, and therefore it behoves us to use it as efficiently as possible.

Some time ago the writer was engaged in examining the question of improving output in a photographic materials factory. One employee complained of constant headaches, and was sometimes absent from this cause. Output was anything but good. The worker was seated at a bench, and the work had to be carried out by artificial light, as she was packing sensitized paper. The lamp had a carbon filament, and was situated about 4 in. or 5 in. above and, perhaps, 15 in. in front of her head. The direct rays did not strike her eyes. She had to wrap the packet of paper in lead foil for export, and after some hours spent in watching, the observer, being just behind the worker, where he could see every movement, had a headache. On thinking the matter over, it occurred to the writer that the headaches were due to eye fatigue caused by the reflected light from the facets of the lead foil. An extemporized shade was made, fitted with green glass (Chance's pot signal), which was fitted over the lamp with excellent results. The headaches disappeared, and output went up by about 10 to 15 per cent.

One cause of poor illumination in factories is the beams and piping which cross ceilings. It is much better for these beams to run the width of the room rather than lengthwise. This is a matter the architect should consider when designing his building. The usual accumulation of belting and shafting absorbs a tremendous amount of light, and in new factories the many advantages of electric drive, either individual or group, should be seriously considered. As a matter of fact, the factory building is too often designed and built with little thought of the processes to be carried out therein, and the writer holds that the design of the building is subservient to the sequence of operations and the layout of the plant. If this were considered first, then the question of the design of the building and the adequate lighting of machinery and work benches could be dealt with. In this connection the lighting of stairways and fire exits should not be overlooked. A limiting factor in connection with natural illumination is that at 20 feet from side windows it must be supplemented by some other means; e.g., from skylights or artificial light. It is possible to overcome some defects of natural illumination by a rearrangement of the machinery and benches. The latter should, as far as possible, be arranged at light angles to the windows.

Sometimes prismatic glass assists in obtaining better illumination, but there is a tendency to glare, which must be avoided at all costs. There are few factories so fortunately situated that at no period of the day does the sun shine directly into some of the windows, causing intense shadows on the one side and discomforting glare on the other. All kinds of measures have been tried with varying degrees of success, the best of which are frosted glass, whether of the ground-glass type or preferably those in which some simple pattern is impressed on the surface. The lower panes of glass should be clear, as by looking out of the window workers have an opportunity of relieving any eye fatigue that may be present. A further psychological factor of importance is that the feeling of being "cribbed, cabined and confined" is lessened. Few of us care to work in rooms from which we have no outlook whatsoever. The beneficent effect of sunlight on the health and the maleficent effect of deep shadow and glare are antagonistic; and some means must be devised to obtain the economic balance between them. A hopeful sign is the introduction of the new glass tried in the Smethwick Schools; unfortunately this glass appears to be very expensive.

Natural light properly diffused throughout has been one of the prime factors in the development of modern American factories, and clearly recognized as a controlling element of design. It limits the width of buildings of more than one story, fixes the heights between ceilings and floors, the area and position of the lights, and controls the selection of the glass required to give a uniform distribution of light. One of the most modern of these factories has an L-shaped form, with the main entrance and offices situated at the corner. It is all on the ground floor, and is lighted mainly from a roof of the saw-tooth shape so common in weaving sheds in our own country. The area is somewhere about 12 acres, and, judging from photographs, the illumination is wonderfully good. The quality of the product of this firm is generally accepted to be the highest. Many of our factories might be described as antiques, and the paucity of natural illumination is such that they ought never to be used other than as examples of how not to do it.

Quite naturally one realizes that the question of expense has to be considered; but this is bound up with another matter, that of adequate depreciation rates. This is outside the scope of this particular article, but so also are many other factors which affect good illumination in factories and workshops. In what ways can the natural illumination of these old factories be improved then? Firstly, by arranging a proper time-table for having them cleaned. Sometimes by adding new windows or increasing the area of the old. Another thing that can be done is to *paint*, not whitewash, both walls and ceilings with a paint giving a hard glossy finish that will not hold dust and dirt. The lower parts of walls, up to a height of about 5 feet, could be a battleship grey or darkish green. The right kind of paint can be swabbed down, which will certainly cost less than the annual whitewashing. Now comes a suggestion which

may be so new as to be startling, but which has been carried out in several factories with conspicuous success. *Paint all the machinery* either *white* or a *light buff colour!* The late Frank Gilbretti is responsible for this idea, and it had precisely the effect he predicted. Not only was the illumination of the factory improved, but machines and equipment were kept cleaner, and consequently in a more efficient state than before. What will appeal more to the manufacturer is that the quality and quantity of output was increased.

It would be presumptuous of the writer to inform readers of this journal of the details of the amount of illumination required for different operations; to describe the distances apart and height from the floor of the lighting points; the different kinds of lamps and shades; but he would most strongly urge those who are specialists to contribute articles to other technical and lay papers on this most important subject. In the practice of his profession he passes through great numbers of factories of all kinds, and rarely does he see any which begin to approach the well-illuminated factory which we all know to be so desirable. It can only be lack of knowledge on the part of many, although perhaps here and there it is callous unconcern.

It has proved somewhat difficult to obtain actual figures of improved output because good lighting has so many other effects which have perhaps overshadowed the question of the desirability of measuring the results obtained. There is undoubtedly a freedom from accident, a great improvement on the health of the worker, and also upon his cheerfulness and will to work; there is decidedly a reduction in spoiled work and an increase of production. The following table is taken from *Engineering Production*, May, 1924:—

Shop.	Average foot-candles Old System.	Average foot-candles New System.	Increased Production Per cent.	Additional Cost of Lighting Per cent. of wages.
1. Pulley finishing ...	0.2	4.8	35.0	5.0
2 Soft metal bearings ...	4.6	12.7	15.0	1.2
3. Heavy steel machines	3.0	11.5	10.0	1.2
4. Carburetter assembly	2.1	12.3	12.0	0.9
5. Jute spinning ...	1.5	9.0	17.0	No data
6. Electric, gas, and other irons	0.7	13.5	12.2	2.5
7. Semi-automatic buffing of brass shell sockets	3.8	11.4	8.5	1.8
8. Piston rings	1.2	18.0	25.8	2.0
9 Letter separating ...	3.6	8.0	4.4	0.6
Average ...	2.3	11.2	15.5	1.9

The following table is compiled from Lighting Data Bulletin, 102A of the General Electric Co.'s Edison Lamp Works:—

REFLECTING POWER OF VARIOUS COLOURS.

Colour.	Used for.	Per cent. of light reflected.
White, New ...	Ceiling ...	82-89
White, Old ...	,, ...	75-85
Cream ...	,, ...	62-80
Buff ...	Sidewall ..	49-66
Ivory ...	Ceiling ...	73-78
*Grey ...	,, and side wall ...	17-63
Light green ...	Side wall ...	48-75
Dark green ...	,, ...	11-25
Light blue ...	,, ...	34-61
Pink ...	,, ...	36-61
Dark red ...	— ...	13-30
Yellow ...	S.de wall ...	61-75
Dark tan ...	— ...	30-46
Natural wood brown stain	— ...	17-29
Light wood varnish ...	— ...	42-49

A grey obtained by mixing lampblack with white gives the lower figure, whereas one obtained from red and green paint with a white base gives the higher. It has also been found that dark surfaces may absorb as much as 90 per cent. of the light impinging thereon. Where all the surfaces, floors, walls, ceilings and machinery are white the intensity of illumination may be as good at some points as that obtainable by direct illumination from windows or skylights.

The Science of Illumination

For some time past a Committee of the Deparment of Scientific and Industrial Research has been directing a number of experimental investigations into the technique and theory of illumination. The reports upon these researches will provide all illuminating engineers with an up-to-date technical library at a very small cost.

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Lighting Economics in its Relation to Electricity Economics

By J. E. ROSENTHAL

(Chief Engineer, Lighting Economics Department, Osram Company, Berlin.)

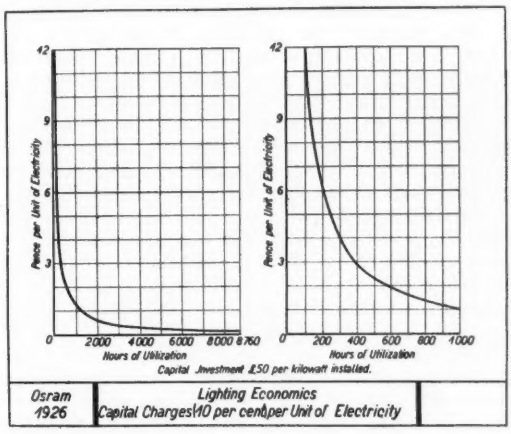
THE importance of lighting economics as a branch of general electricity economics is very little realized to-day. Nearly all central stations are strongly opposed to a heavy lighting load; they spend much pains and trouble to increase the sale of heating and power current, but frequently neglect the propaganda for lighting current altogether.

It is absolutely necessary that lighting economics takes its due place in the realm of electricity economics. Lighting economics is the most important part of electricity economics, because for the production of light electricity to-day holds a pre-eminent position, whereas for the supply of heat and mechanical energy electricity has strong competitors in other forms of energy, such as gas, oil, coal, wood, etc. For this reason the supply of lighting current is a civic duty for electricity companies, although one naturally cannot expect them to lose money over it.

Electricity to-day is the most highly refined form of energy which we possess. For this reason it should be applied in all such cases where other coarser or rawer forms of energy do not prove satisfactory, be it for certain undesirable features, such as waste gases, waste heat, difficulties in transport or distribution, etc.

The only disadvantage of the electrical form of energy is the difficulty of storage. For this reason electricity must be consumed in the same instant in which it is produced. In addition to this, comparatively expensive material is required for the efficient transport of electricity, namely, copper or aluminium, and hence this transport of electricity involves a considerable outlay of capital, whose interest, redemption, and other fixed charges limit the effective radius of current distribution. The cross-sections of electric conductors increase the longer the line, whereas the section or weight of rails and the capacity of the rolling stock remain the same, irrespective of the distance of rail transport. For this reason the capital investiture of railways increases approximately according to a linear function of the distance, but the capital of electric transmission increases in a higher ratio. Dr. Schulze-Auma, "The Economic Range of Electric Transport in 1925," E.T.Z., November 10th, 1926, arrives at the conclusion that up to about 125 miles, and with the use of low-grade coal under the boilers of the central station, the transport of energy in the form of electricity is cheaper than the transport of high-grade coal of about 13,000 B.Th.U. The application of very high transmission voltages, say 200,000 volts, is not yet practically proved, and hence the problem of electricity distribution over very long distances is neither technically nor economically solved at the present moment. The technical development in long-distance high-pressure gas distribution and coal liquefaction may possibly render the transport of energy over longest distances through pipe lines cheaper than rail, water, or electric transport, so that perhaps in future the coarse distribution of energy to the different centres of consumption will be effected through pipe lines in the shape of oil or gas, and only the fine distribution up to the ultimate place of consumption will be done electrically.

Owing to the fact that electricity is practically not storable and must be used at any distance from the generating station at the same instant at which it is produced, the problem of constant utilization becomes much more important for electricity economics than in any other economic field. The capital invested in the central station and in the distribution system requires considerable interest and fixed charges annually, and, therefore, the fixed charges per unit of electricity sold decrease with the number of hours during which the entire plant is utilized. Supposing, for instance, the capital investiture of the central station and distribution system to be £50 sterling per kilowatt, and the annual interest to be 10 per cent., i.e., £5. In this case the fixed charges per unit of current sold, with a utilization of only 100 hours per annum, would be 1s. per unit of electricity; with 1,000 hours' utilization annually they would become 1¼d. per unit, and with full utilization of 8,760 hours they would amount to less than ¼d. per unit.



The influence of the hours of utilization upon the price of current is very little recognized by the general public; there are frequent complaints in the press that electricity companies charge usurious prices. Upon close examination this accusation is very rarely justified. Recently, for instance, the manager of a central station in Germany was attacked in the press, because he bought current in bulk at ¼d. per unit and sold it at 6d. per unit. This procedure was said to be usurious. Upon close examination this case is as follows:—

The municipal station in question buys high-tension current of 100,000 volts at little over ¼d. a unit. It must step this voltage down to domestic voltage in its own transformer stations, and must distribute it to its customers. The capital investment of these transformer stations and of the distribution system in the town may be taken at approximately £25 per kilowatt. If the annual fixed charges are taken at 20 per cent. of this capital investment, which would include interest and redemption, administration charges, meter reading, no load- and hysteresis-losses, etc., it will be seen that about £5 per kilowatt must be paid annually. As many customers in this particular town, more especially for domestic and commercial supply, use current only during 250 hours a year, the fixed charges for this category of customers amount to 5d. per unit of electricity, to which must be added the high-tension current cost with a little over ¼d. per unit. It will be seen that in the case in point the cost of current to the municipal company amounts to over 5¼d., and it would be unjust, therefore, to call a price of 6d. per unit usurious.

A discussion regarding the justice of a certain electricity rate is, therefore, impossible without due consideration to the hours of utilization.

No agreement has yet been reached as to the correct definition of what is meant by utilization. In most cases utilization is defined as central station utilization, i.e., the electric work supplied by the central station annually in kilowatt hours divided by the peak load of the central station in kilowatts. This utilization factor is obtained empirically, and contains the diversity factor, inasmuch as the different customers require their maximum at different times, so that the peak load of the central station is much lower than if all consumers had their maximum demand at the same time.

Consequently, with a certain amount of units supplied by the central station per year the utilization factor appears higher, because the peak load is smaller. Hitherto central stations endeavour to improve the diversity factor, i.e., to keep the peak load as low as possible, thus increasing the factor of utilization of the central station.

Another definition of the utilization factor is either referred to the connected load of the customer or to the maximum demand of the customer. The aim of lighting economics is:—

1. To provide ample illumination consistent with the economic and cultural requirements of each customer; and
2. To utilize electricity during the time when no lighting current is required for other domestic purposes, thus obtaining a high utilization factor in relation to the connected load.

In this manner the lighting requirements of the customer, i.e., lighting economics, is made the basis of electricity economics for domestic purposes. Let us assume, for instance, that a customer requires 600 watts for light, and that he uses this load for an average of 500 hours during the year. The capital investment of the electricity company up to the terminals of the consumer may be taken at £50 sterling per kilowatt, and the capital charges at 10 per cent. In this case the capital charges, with a utilization of 500 hours, amount to 2½d. per unit of electricity. Let us further assume that the electricity company buys power in bulk at ¼d. a unit. It would then follow that the lowest price at which electricity could be charged to a customer using it 500 hours per annum would be 3d. At this price electric light is cheaper than any competitor. Gas, oil, or candles would be much more expensive. Now if the customer uses his plant also during the time when he does not require electric light the current during this period could be supplied at a much lower rate, provided, of course, that it does not exceed 600 watts. Since interest and other fixed charges are paid out of the sale of lighting current —which is quite justified, because light cannot be produced cheaper in any other way—the rate during the time when electricity is not used for lighting purposes can come very close to the actual cost price of ¼d. per unit. Under these circumstances it would be possible to the electricity company to sell current for domestic purposes, such as cooking, heating, washing, ironing, refrigerating, etc., at a rate slightly over ¼d. per unit.

As has been said before, electricity is a highly refined form of energy, which is destined throughout our civilized world to replace domestic help and menial service in the household.

Not only in America, but also in most European countries, servants are difficult to get and expensive to keep. An amount of £60 to £80 per year for keeping a servant seems by no means excessive, and yet the electricity bill in the same house probably only amounts to one-tenth of the sum. To-day practically all domestic work, including charing, floor polishing, dish washing, general laundry work, drying, ironing, cooking, heating, etc., can be done electrically, so that by means of these labour-saving electric appliances the housewife herself, or with the assistance of one domestic servant, can do the entire housework for a large family. Of course, this necessitates for the women just as perfect machine tools in the house as man uses in the execution of his professional work.

It will be seen that an increase of the utilization factor in the household is possible and desirable, and that thereby the cost of electricity can be reduced much more than will be possible by an increase of the thermo-dynamic efficiency, or the size of the units in the central stations, etc.

The value of the diversity factor for the central station will naturally be reduced, because if all customers use electricity for nearly 24 hours per day it will be impossible for customer A to have his maximum demand at a different time of the day from customer B. This will render all those electricity rates obsolete which favour customers with large installations, because their maximum demand is low, and will in all probability not coincide with the maximum demand of other customers.

A just electricity rate, to my mind, is one which is based on a relatively higher price for lighting current, but which allows very high discounts for increased hours of utilization, so that when a customer uses his plant for 5,000 to 6,000 hours per year he would come down to a price of current as low as ¼d. per unit of electricity.

Such a rate possesses all those qualities which are considered desirable from the point of view of lighting economics, namely:—

1. The rate must be just, both to the central station as also to the customer, i.e., the central station may earn an adequate profit, but should charge as low a price as possible.
2. The rate should possess propaganda value, i.e., it should not hinder the application of electricity, but should further it. This is attained by giving an increasing discount with increasing hours of utilization.
3. The method of charging for current must be easily understood, more especially by the women who pay for the greater portion of domestic current out of their household budget.

The demand rates hitherto used, which contain a certain amount for fixed charges, another amount for maximum demand, and a third amount for the actual number of units consumed, are not readily understood, more especially by women, and are often considered unjust, as it is difficult to see why anybody should pay the electricity company when he is absent from his house for a few months.

The advantage, however, of obtaining a discount which increases with the hours of utilization will be appreciated by every layman. The discounts might be given once or twice per year in the shape of refunds, so that the electricity company would constitute a sort of savings bank. An arrangement might even be made whereby these refunds are paid direct into a savings account, and in this manner the economic importance of the electricity company is much enhanced, and perhaps a similar goodwill is created as is done in America by the system of customer's ownership.

The above are merely general observations which would have to be made subject to a careful scrutiny in each case in consideration of the prevailing conditions. Central stations should make a careful analysis of the various categories of customers, such as commercial, industrial, domestic, etc., showing the capital investment and revenue required for each class. Such an analysis will be of great interest, and will help the central station managers to decide which class of customer is the most valuable to them and deserves most consideration.

Conclusions.—Electricity to-day is indispensable for the production of light, and, therefore, it is the civic duty of electricity companies to supply lighting current of sufficient quantity and quality. Central stations can naturally not be expected to lose money in supplying lighting current or to supply lighting current wholly or partly at the expense of other categories of consumers.

Next in importance in the field of electricity economics come all those applications in which heat energy is converted into mechanical energy. The roundabout way via electric energy may be justified the easier the smaller the driving motor. But even in case of large and largest motors, such as electric winders, pumps, fans, etc., electric operation may be justified if other advantages accrue, such as ease of regulation, small space required, etc.

The third important application of electricity is for heating and cooking purposes, mainly in all such cases where the high thermal efficiency of electric heating and cooking apparatus, notwithstanding the comparatively small thermo-dynamic efficiency of the electric central station, counterbalances the low thermal efficiency of non-electric heating and cooking apparatus.

The application of electricity for the second and third category necessitates low prices of current which, however, cannot be attained so much through an increase of the thermo-dynamic efficiency of the central station, through increasing the size of the central station units, or by improving the power factor, as by an increase of the hours of utilization. For this reason an electricity rate is recommended, which allows for higher discounts according to the increased hours of utilization, so that with a utilization of 5,000 to 6,000 hours per annum, such a low rate of current is attained that the application of electricity becomes practical everywhere.

TRADE NOTES & ANNOUNCEMENTS

GETTING READY FOR THE DERBY.

NIGHT-WORK ON THE NEW GRAND STAND BY THE AID OF B.T.H. FLOODLIGHT PROJECTORS.

Much public interest has been taken in the magnificent new grand stand now in course of erection on Epsom Downs, which, when it is completed, will be the largest in this country.

The contract was entrusted to Messrs. Howard & Co., of Broad Court, Covent Garden, W.C.2, who at once commenced work on the foundations. Owing to the intervention of the coal strike and the consequent scarcity of iron and steel, it became evident that in order to complete the new grand stand in time for the 1927 Derby, night-work would be necessary. Therefore, the electrical contractors on the job, Messrs. Bell Bros., 7, Camomile Street, E.C.4, took the matter in hand, and, in consultation with the British Thomson-Houston Co. Ltd., made arrangements to floodlight the building operations.

For this purpose 16 B.T.H. type 786 Floodlight Projectors, with diffusing mirror reflectors and 1,000-watt Mazda lamps, were mounted on eight masts, ranging in height from 10 feet to 40 feet, erected at suitable points around the site of the new building. As can be seen in the photograph, each mast carries two projectors, one at the summit inclined downwards to cast its beam of light on the top of the work in progress, and the other mounted lower down and arranged at an angle according to the lighting requirement in its vicinity. By the use of these B.T.H. Floodlight Projectors almost daylight conditions prevail throughout the night, with the result that the hourly progress after sundown is practically equal to that shown in the daytime.

Erecting the new Grand Stand at Epsom, with the aid of B.T.H. Floodlight Projectors.

TWO RECENT APPLICATIONS OF FLOODLIGHTING.

From the General Electric Co. Ltd. we receive particulars of two novel floodlighting installations. The first relates to Glentworth Bay, where the Weston-super-Mare authorities are engaged on a scheme to lock the tide water. Night work is being facilitated by the installation of a number of G.E.C. projectors equipped with 1,000-watt Osram lamps. Ample light is available for all operations, the illumination extending halfway across the bay—which exceeds a quarter of a mile across.

The other item is the illumination of a large flag on a pole 40 feet high, erected on the roof of the Ambassadors Hotel. A series of projectors equipped with 200-watt Osram gasfilled lamps are mounted at four points on the roof. After dark the pole and the flag are brightly illuminated, the name of the hotel on the flag standing out in a striking manner.

CONTRACTS CLOSED.

The following contracts are announced :—

MESSRS. SIEMENS AND ENGLISH ELECTRIC LAMP CO. LTD. :

Aberdeen Line (*Geo. Thompson & Co. Ltd.*); for the supply of Siemens vacuum, gasfilled and carbon-filament lamps during the next six months.

Great Western Railway; for the supply of Siemens gasfilled lamps during the period ending October 31st, 1927.

MESSRS. METRO-VICK SUPPLIES LTD. :

Admiralty; for " Cosmos " Group III flashlight lamps.

London, Midland and Scottish Railway Co.; for " Cosmos " vacuum train-lighting lamps.

GENERAL ELECTRIC CO. LTD. :

Elder Dempster Line; for the supply of Osram metal-filament, vacuum, and gasfilled lamps for 12 months.

Auckland Electric Power Board; for the supply of over half a million yards of triple-braided G.E.C. cable, to the value of several thousand pounds.

" HAILWOOD & ACKROYD LTD."

Readers will be interested to note that from January 24th onwards the name of Messrs. Ackroyd & Best Ltd., of Morley, Leeds, has been altered to " Hailwood & Ackroyd Ltd." Mr. Hailwood continues as Managing Director of the Company, and the staff remains the same, the name having been altered as a compliment to Mr. Hailwood, who has been the main organizer and inventor of the Company for many years. The Company will carry out the contracts and obligations incurred under the name of Ackroyd & Best Ltd., but in future communications, cheques, etc., should be made out to the Company under the new name.

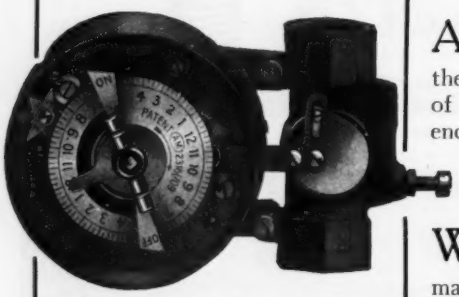
St. Matthias' Church, Liverpool.

ST. MATTHIAS' CHURCH, LIVERPOOL.

The lighting of sacred edifices in the past has not been beyond reproach, but an excellent example of church lighting is illustrated here—St. Matthias' Church, Liverpool—lit throughout with Philips Argenta Lamps.

The pleasing effect obtained in the lighting of the chancel is especially noticeable; the pure, silvery, white light emitted by the Argenta lamp harmonizing perfectly with the interior decorations of the church.

"People buy where the light is bright."



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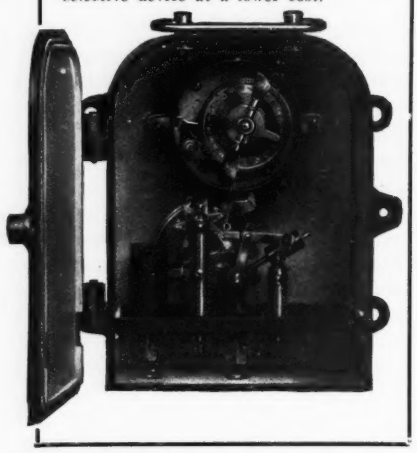

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LIGHT WITHOUT DAZZLE.

The question of dazzle for the night-driving motorist is one which has been carefully studied by manufacturers, and many methods have been employed in the past which have, to a certain extent, been fairly successful, but they do not entirely solve the problem.

The leading lamp manufacturers have for some time past been experimenting to produce a bulb which eliminates glare and dazzle completely and avoids the necessity for dimming, dipping, or blocking-out. We understand that Messrs. Philips Lamps Limited have now placed on the market an efficient anti-dazzle automobile headlamp which is strongly recommended to motorists for night-driving.

Fig. 1 shows the Philips Duplo Lamp. This headlamp which is gasfilled is provided with two filaments of equal lighting power—one furnishes a powerful light for normal use, and the second is fitted inside a metal cup which throws the rays toward the upper part of the reflector, from whence it is reflected on to the road, thereby avoiding glare. As both filaments are of the same candlepower, there is no reduction in the amount of light when switching over from one to the other before passing an oncoming car.

The non-dazzling beam of light which can be produced by the Duplo lamp is also excellent for driving in foggy weather. The second type of headlamp (see Fig. 2) is the Philips Twin Filament Auto Bulb Headlamp, which is also provided with two filaments of exactly the same wattage, one of which is situated at the focal point of the reflector, whilst the other is above the focal point. By means of a change-over switch the filament at the focal point is extinguished and the other lighted. This gives the effect of a dipper.

The lamp is also provided with a corrugated glass bulb, which eliminates all internal reflections, thereby reducing to a minimum all glare and dazzle. These headlamps are supplied in two sizes only, 6/7 volt 18 and 18 watts and 6/7 volt 24 and 24 watts with A.S.B.C. caps.

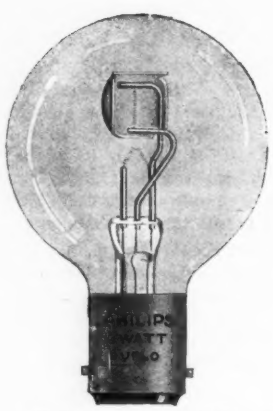


FIG. 1—Philips Duplo Lamp.

FIG. 2.—Philips Twin Filament Auto-Bulb Headlamp.

SPOOK RADIO-ACTIVE UTILITIES.

On various occasions the possibilities of radio-active self-luminous materials have been discussed before the Illuminating Engineering Society. From Messrs. Allardstown & Co., of Upper Norwood, we receive a leaflet describing the use of this material in various ways. The first and most obvious application is for the covers of switches, so that they can be located in the dark. Luminous crescents to be mounted over keyholes, bells, etc., can also be obtained. Amongst other "Spook" devices we also note luminous names of houses, rear discs for cyclists and hand-signalling discs for motorists, the latter to be worn attached to the glove.

There would seem to be considerable possibilities for devices of this kind, provided that the necessary brightness can be maintained at a reasonable cost of luminous material.

A Gas Exhibit at the Alexandra Palace

Arranged by the Tottenham District Light, Heat and Power Company

THROUGH the enterprise of the Tottenham District Light, Heat & Power Co. two large galleries at the Alexandra Palace have been devoted to the staging of a well-arranged gas exhibit, which reflects great credit on the Company and their Distribution Superintendent, Mr. S. B. Chandler

The main stall of the Company bears the motto " Gas —the Symbol of Service." In addition to a comprehensive exhibition of by-products of gas manufacture, a complete gas-testing plant is being demonstrated daily by a qualified chemist. The stand is lighted by three Sugg Surbiton lamps on the interior and three Sugg outdoor lamps on the exterior, controlled by Sugg distance-control devices, and also Hortsmann time clock. This exhibit is specially adapted to impress consumers with the care exercised in the testing of gas, as is illustrated by the framed certificate of the Gas Referees.

The model house (see Fig. 1) is also an effective exhibit, fitted throughout with modern gas-lighting fittings pneumatically controlled; needless to say, gas fires and geyser for hot-water supply are also in evidence. On other stands the requirements of kitchen, bathroom, dining-room and drawing-room and office are further illustrated. The dining-room receives illumination from a floor lamp, table lamp, and candle brackets with shades, harmonizing with the general scheme of decoration.

In the eastern corridor some of the newest types of street lamps are exhibited by the Company (see Fig. 2), and interesting demonstrations are being arranged to illustrate the applications of gas for public lighting. In the hall adjoining the main exhibition a number of columns have been erected, each having at its apex a different form of lamp suitable for main and arterial roads, junctions, first and second-class roads and parade lighting. Each of these is controlled by means of a clock apparatus which automatically lights and extinguishes the lamps at predetermined times. With these devices practically any form of control can be exercised—for instance, shop lights which do not operate on early-closing days and Sundays can be made to miss two days a week. This system has been universally adopted throughout the area served by the Tottenham District Light, Heat and Power Co., and we understand that it is proving very satisfactory in use.

Special attention was also drawn to the danger-sign lantern glazed with opal glass and red lettering, which forms a useful road sign both by day and by night. Yet another exhibit in this section was a 15-ft. reflex lamp column, fitted with a 10-light lamp and red-glazed panels, which is considered particularly suitable for refuge lighting.

By the courtesy of *The Gas Journal* we are including two illustrations showing respectively the model house and the street-lighting display.

Other features of the exhibition include the series of cookery lectures by the Company's lady demonstrator. In the general display there are approximately thirty stands devoted to cooking, lighting and heating, so that visitors have every opportunity of seeing what can be done with gas to-day.

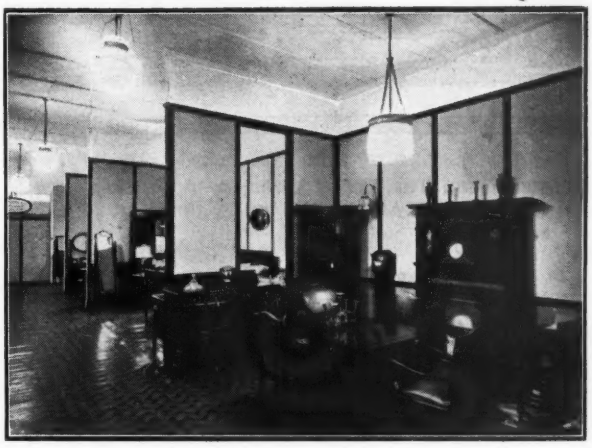


FIG 1.—Gas-equipped Model House.

FIG. 2.—Types of Public Lamps in the Tottenham Company's District.

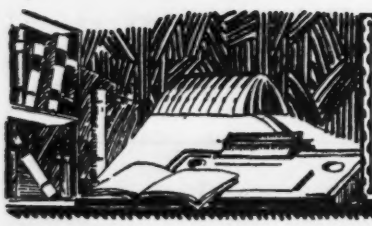
Change of Name and Amalgamation

We are informed that the business of the Lamplough Daylamp Ltd. has now been amalgamated with Halstead Hanby & Co. Ltd., under the new style and title of Restlight Ltd. (Lamplough Illuminating Products), 40, Norfolk Street, London, W.C.2.

A Novel Window Display

Merchants will go to considerable trouble nowadays to devise a window display that can be relied upon to attract public attention. But one of the strangest displays was surely that recently staged by the Public Service Company of Colorado. The window was occupied by Navajo Indians, a head medicine-man and four assistants, who squatted in native costume, and, by using sands of various colours, told the story of the Ye-Be-Chi dance. Starting before sunrise one day the Navajos stopped before sunset, according to religious custom, and finished the next day. The Ye-Be-Chi dance lasts nine days. Great crowds watched the performance of the Indians.

The commercial results are not stated, but the exhibition must at least have been a good advertisement for this gas company.



REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED

COLOUR-MUSIC; THE ART OF LIGHT; *by A. B. Klein, M.B.E. (Crosby, Lockwood & Son, London,* 1926; *pp.* 286; *Figs.* 20; *plates* 22. 36*s. net.*)

In the introduction to this work Major Klein foreshadows the Art of Light as a natural development of the modern movement in painting. The special province of this book, however, is the use of coloured light, particularly in the form of colour-music, a term which he prefers to "mobile colour" used by early investigators. The recognition of the analogy between the chromatic scale and the musical octave is of early date. The conception of colour-music goes back to 1763, when it was clearly outlined by Louis Bertrand Castel, who described his discovery with infectious enthusiasm. Many other workers in this field followed. The most noteworthy practical efforts were the colour-organ of Professor Rimington, who died in 1918, and the clavilux of Wilfred, in the United States. Public demonstrations of both forms of apparatus met with some success, though it may be doubted whether a sequence of colours can at present compete with a concert as a form of entertainment. The value of coloured light as a supplement to music and drama is, however, already well established.

In Chapter III the author outlines the idea of colour-music in greater detail, and in Chapter IV its relation to psychology. The closeness of the analogy is shown by the frequent use of words denoting visual properties in describing music. The composer Scriabine used to assign definite colours to various compositions, and even to the various keys. The author quotes the views of a considerable number of authorities on the problem of colour harmony, in the form of a historical review, and he then proceeds to the discussion of the nature of colour-music, involving a well-defined scale of colours, which may be presented in various combinations and shapes. This chapter is effectively illustrated by a coloured plate showing a chromatic keyboard with the keys coloured with the hues of the light controlled. Very interesting also are the records of mental associations of various colours. Observers agree with remarkable unanimity in assigning to the red and orange a cheerful and stimulating influence, whilst greens and blues are sedative and the violets are associated with melancholy and gloom. These mental influences have been made the basis of treatment of neurasthenia and mental disorders, in some cases with good results.

To readers of this journal one of the most interesting chapters is that dealing with stage lighting. Here reference is made to Mr. J. B. Fagan's well-known paper before the Illuminating Engineering Society, the Schwabe-Haseit system, and the cyclorama, the Klein colour projector, etc. Another recent apparatus described is the ingenious "Mutochrome," whereby any pattern can be projected on to a screen, and the colours varied to any desired degree. The subsequent chapter on "Instruments, Past and Future," contains illustrations of various colour-organs and other apparatus, and in conclusion the author reviews various possibilities in the use of coloured light for decorative purposes, in the kinema theatre, etc. Throughout the book Major Klein displays considerable knowledge of art and music, as well as the physical aspects of the subject, in connection with which frequent references to Mr. Luckiesh's works on colour are made.

References are given at the end of each chapter. The book is excellently printed and equipped with a large number of striking illustrations, including a number executed in colour.

MODERN ELECTRICAL ILLUMINATION, *by Cyril Sylvester and Thomas E. Ritchie, with a foreword by R. A. Chattock.*

The above work is announced by Messrs. Longmans Green & Co. The price will probably be 42s. net.

The Practical Electrician's Pocket Book. (*S. Rentell & Co. Ltd.,* 1927, *pp.* 602; 2*s.* 6*d., net.*)

The Practical Electrician's Pocket Book once more makes a welcome appearance. The 1927 edition has been considerably revised, and we note that the sections on Illumination and Lamps have been revised by Mr. W. J. Jones. Definitions of the chief terms used in connection with illumination are quoted from the B.E.S.A. Glossary, and explanations are aided by effective illustrations. The sections on Gas, Oil and Petrol Engines have been thoroughly overhauled. The chapter on Wireless Telegraphy has been brought up to date by Mr. A. P. Welch, and new sections on Testing, Earthing, and the Jointing of Lead-covered Cables have been written by Mr. G. W. Stubbings. The pocket book contains a considerable amount of condensed information, over 600 pages of matter, besides the Diary.

Collins's Engineering Diary. (*Wm. Collins, Sons, & Co. Ltd., Glasgow,* 1927, *pp.* 128.)

Another welcome arrival is the familiar *Collins's Engineering Diary,* which is of a convenient size for the pocket, is bound in real pig-skin, and deals with general engineering. This, too, contains a great deal of useful tabular matter, and the space is used to the best advantage. We understand that the second edition of this little diary is now practically sold out, so that evidently its popularity is maintained.

We have also to acknowledge the receipt of a book of considerable general interest, *Thirty Years in the Public Service,* by Miss Rose E. Squire, O.B.E., late Deputy Principal Lady Inspector of Factories. An introduction is furnished by Sir Edward Troup, K.C.B., K.C.V.O., and the work is published by Messrs. Nisbet & Co. Ltd. We propose to review this book in our next number, but meantime we may say that it contains a remarkably graphic and interesting account of experiences in connection with the inspection of factories, with which Miss Squire has been associated from its very early stages. To readers of our journal Miss Squire's name is familiar as one who has taken a very deep and sympathetic interest in industrial lighting, and has joined in discussions before the Illuminating Engineering Society on this subject.

PHOTOMETRY

BY

JOHN W. T. WALSH

M.A. (Oxon.), M.Sc. (Lond.), A.M.I.E.E., F.Inst.P.

Member of the National Illumination Committee of Great Britain; General Secretary of the International Commission on Illumination.

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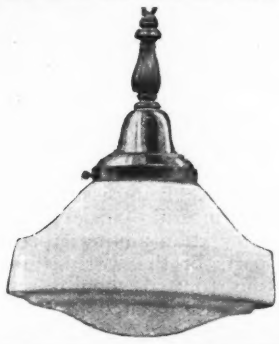

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